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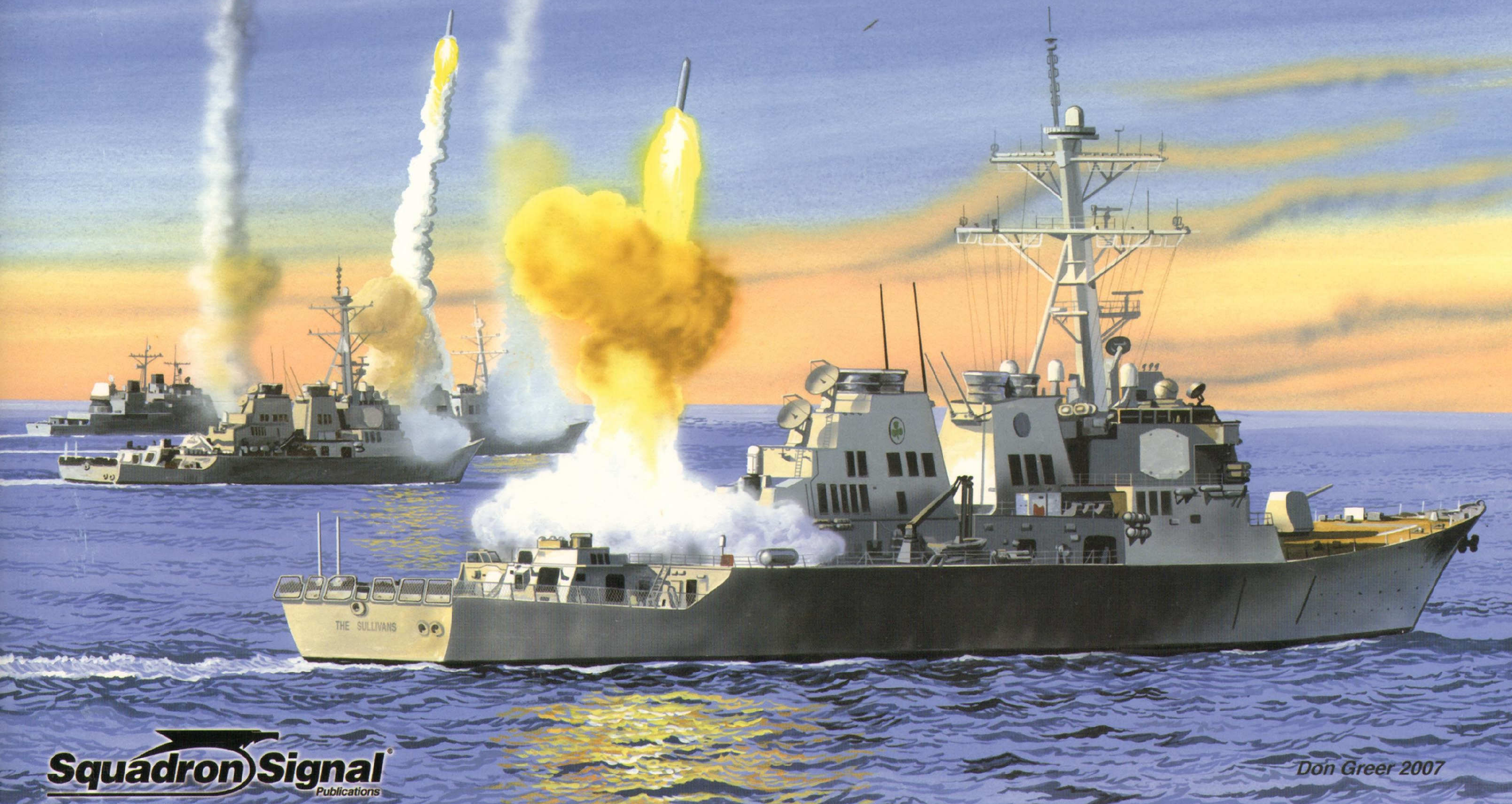
Arleigh Burke-Class
Guided Missile Destroyers

Color Series
Warships In Action No. 31



Squadron Signal Publications

Don Greer 2007

Arleigh Burke-Class
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By John Gourley

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Cover paintings by Don Greer
Illustrations by Ike Anderson

Acknowledgements

Lou Drendel — for his help in getting me started.

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A.D. Baker III — for the excellent line drawings of DDG-51 and for his time spent editing, advising, and providing me with accurate and timely data.

The crews of *Porter* (DDG-78) and *Mason* (DDG-87).

Photo credits

A.D. Baker III collection, Bob Dorr collection, U.S. Navy, RCA, U.S. Naval Institute, Todd Shipbuilding, Northrop Grumman Corp., John Gourley

Dedication

To the crews of *Arleigh Burke*-class destroyers on duty and to all who have preceded them.

Title page: Stout (DDG-55), preparing for a strike group photo exercise, is seen from the carrier *George Washington* (CVN-73). (*U.S. Navy Photographer's Mate Airman Apprentice Jennifer Apsey*)

Front cover: During a missile exercise, *The Sullivans* (DDG-68) fires an SM-2 missile at incoming simulated hostile drones. Behind *The Sullivans* are *Carney* (DDG-64), *Roosevelt* (DDG-80), and a *Ticonderoga*-class cruiser, *Vicksburg* (CG-69).

Back cover: Arleigh Burke (DDG-51) gets under way in rough seas.

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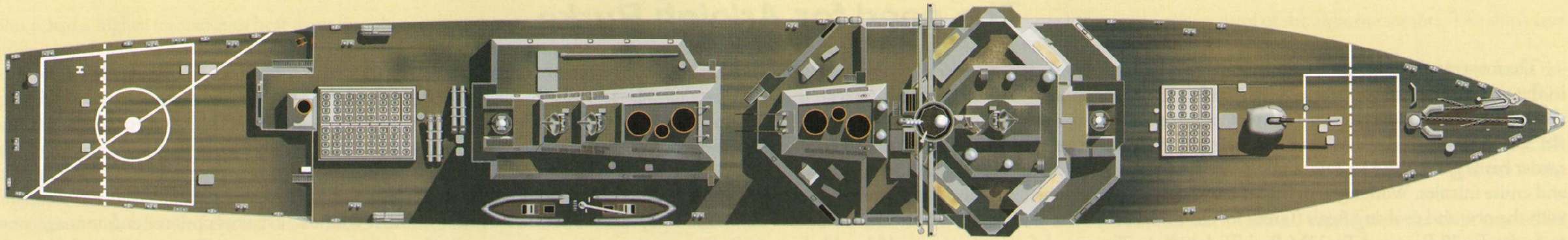
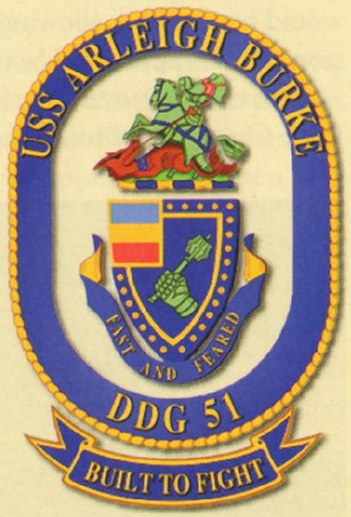
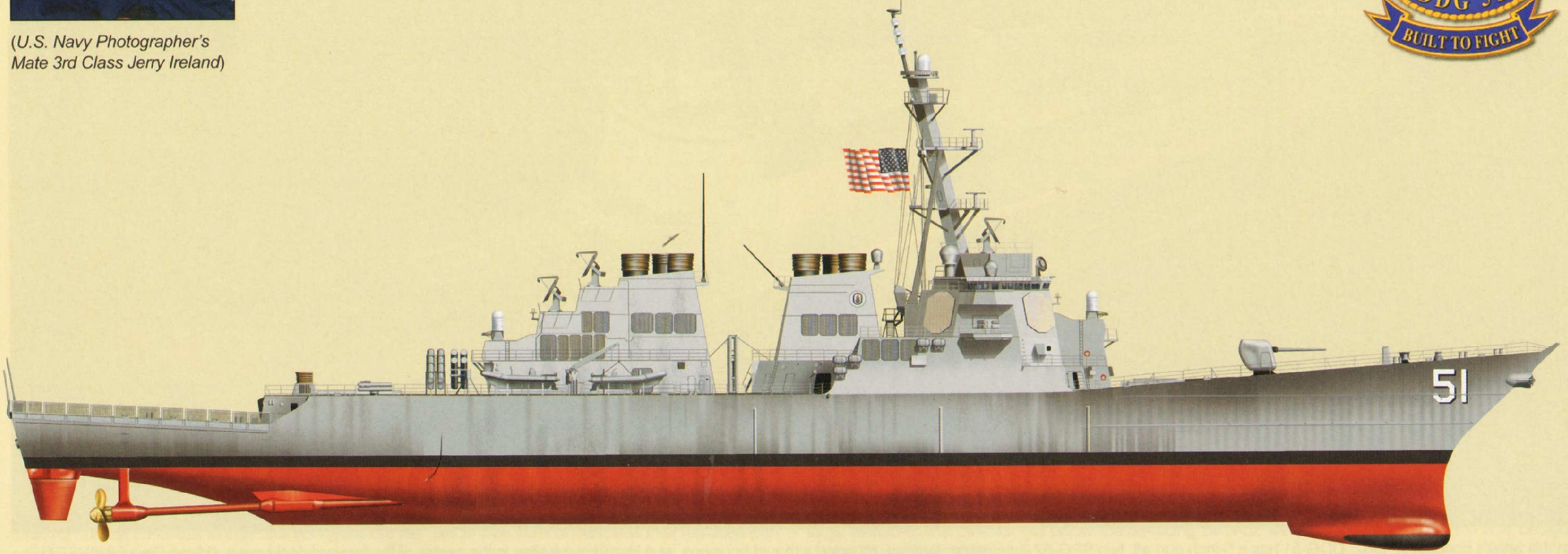


(U.S. Navy Photographer's Mate 3rd Class Jerry Ireland)

At left, Adm. Arleigh A. Burke looks out from the bridge of the ship named after him in Bath, Maine, on 12 September 1990. The *Arleigh Burke* was the first of its namesake class of guided missile destroyers, receiving her commission on 4 July 1991. Her motto is "Fast and Feared." Her crest, at right, is outlined in blue and gold, signifying Adm. Burke's achievements in battle. The fist and mace symbolize the ships' offensive and defensive power. Adm. Burke's Destroyer Squadron 23, represented by the border of 23 ovals, was the only U.S. destroyer squadron to receive a Presidential Unit Citation, signified by the canton of blue, yellow, and red. The mounted figure of St. George signifies Adm. Burke's victory over Japanese naval forces in the Battle of Cape St. George. The gold cross on St. George's mantle represents the Navy Cross awarded to the admiral, and the red sea dragon symbolizes Japanese naval power assaulted by forces under (then) Capt. Burke's command.





The need for *Arleigh Burke*

The most capable and sophisticated destroyer class in the world, *Arleigh Burke* had its beginnings in the mid-1970s, the result of a Naval Sea Systems Command (NAVSEA) research project. In the years following the Vietnam War, cost and size constraints were dominant factors motivating the ship design process. The new destroyer had to be effective as an anti-submarine escort for carrier battle groups and be able to engage and neutralize airborne threats, such as Soviet bombers and cruise missiles. Working with carrier-based fighters, these guided missile destroyers, equipped with the new and evolving Aegis (Greek for shield) radar system, would deliver a knock-out blow to Soviet Tu-20 Bear and Tu-22M Backfire bombers. The two defensive layers would be able in theory to destroy not only the incoming bomber force, but also any cruise missiles the bombers would have launched. If the defense were successful, the specialized Soviet Naval Aviation force would be defeated, allowing allied merchant ship convoys to reach Europe to help NATO forces stop a Soviet land attack across Western Europe.

The new destroyer was also intended to replace older ships of several classes due for replacement (e.g., *Charles F. Adams*, *Belknap*, *Leahy*, and *Mahan*) with one modern type.

After several conceptual designs had been proposed and rejected, 12 baseline descriptions of the new ship were reviewed in the late 1970s. Some of the descriptions were based on modifying current designs in service such as the *Perry*-class frigate, *Spruance/Kidd*-class destroyers, and the *Ticonderoga*-class cruiser. The new ship was to have electric drive, Mk 13 single-armed mechanical missile launchers or the Vertical Launch System (VLS), offering a large volume of weaponry in as small a space as possible. The 12 descriptions included various configurations of radar and electronic equipment. Gun, fire control, combat controls, aviation options, and tonnage were spelled out in the various plans as well. Generally, weight was given from 6,000 to 6,500 tons light, with an average 8,000 tons fully loaded.

Debate centered on the embarking of helicopters; one line of thought was that an assembled carrier surface task force would have ample helicopters. Deleting the aviation capability meant a shorter, smaller hull that would be cheaper to build. That would allow more ships to be built. Aluminum hulls were considered because they were lighter, but they were more susceptible to combat damage. Steel construction was cheaper, stronger, and more resistant to combat damage,

In this artist's concept in 1982, DDG-51 has a 5-inch gun aft, two SPG-62 illuminators forward, rounded exhaust housings, and Harpoon missiles in the center of the forward deckhouse. (*Vince Piecyk/NAVSEA*)

plus it had a higher resistance to heat from fires than aluminum. A disadvantage to steel was that, although stronger, heat would be readily conducted to other compartments.

In August 1979, the chief of naval operations (CNO), Adm. Thomas B. Hayward, officially ordered studies of an Aegis-equipped, missile-armed DDGX to augment the *Ticonderoga*-class cruisers already in service. Not only would the new ship offer increased defenses as part of a carrier battle group, it also would be able to perform independent operations in areas of light hostile action.

Studies focused on five concepts. Ship 1 was a design with cruiser-common features. Ship 2 was offered with advanced electric drive. Ship 3 had midsize dimensions. Ship 4 was smaller than Ship 3, and Ship 5 was a VLS-armed frigate. Various subconcepts emerged from the five. Ship 3A became the most attractive, with the Aegis system and a mix of various electronic fits and weapon arrangements. After a review, Adm. Hayward favored the Ship 3A concept but ordered costs be kept below that of a *Ticonderoga* unit.

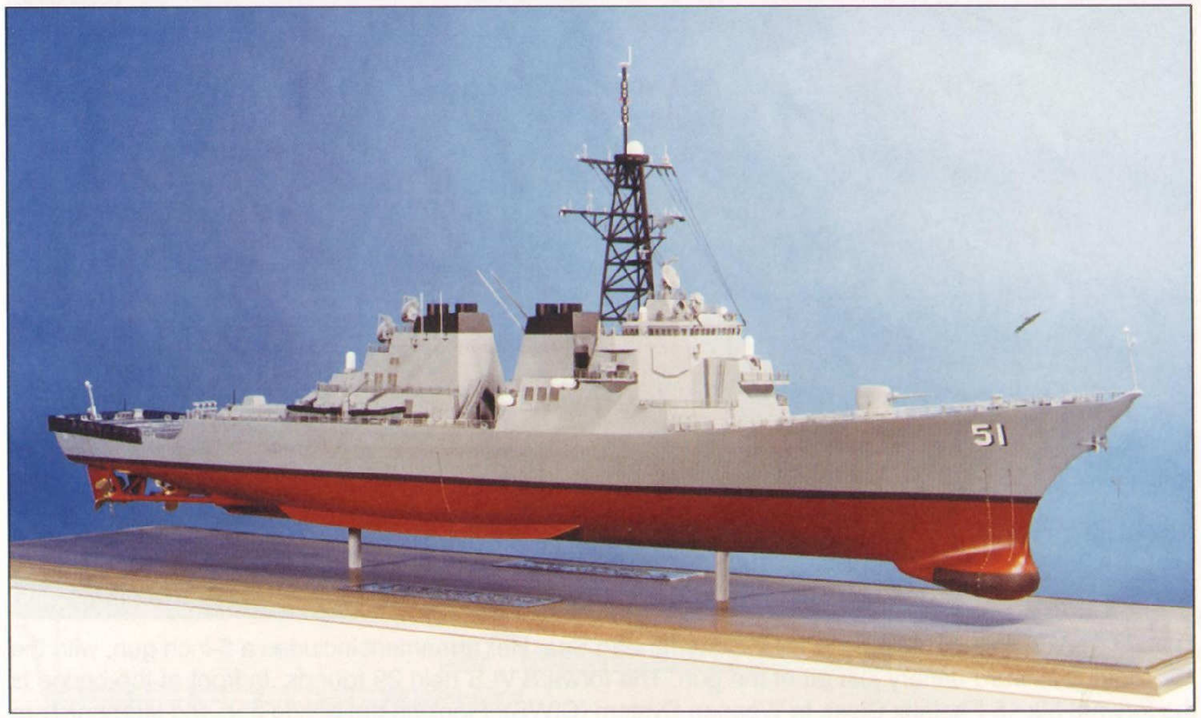
Drawings of the new ship were presented in January 1980, showing a waterline hull length of 479 feet and a 60-foot beam. Fully loaded weight was 7,400 tons. Primary armament was contained in 96 vertical-launch cells. (A-module was forward with 32 rounds, and B-module was aft with 64 rounds. These were later reduced to 90 cells with the addition of two loading cranes that took up the space of three cells each fore and aft.) Other armament consisted of two quadruple Harpoon launchers, two Phalanx close-in weapons, two triple Mk 32 torpedo launchers, and a single 5-inch gun aft. Three LM-2500 gas turbines provided propulsion in an electric drive with one turbine adapted with Rankin Cycle Energy Recovery (RACER) technology (a means of increasing gas turbine efficiency). Three diesel generators gave auxiliary power. In a compromise, helicopter facilities were included without a hangar to provide a landing pad for rearming and refueling only. Data links would give control of the airborne sensors. The ship's cost was estimated at $550 million.

Early in 1981, the DDGX design moved ahead, primarily driven by the desire to keep the ship's size under control. Weight was decreased by 1,000 tons, and length was frozen at 460 feet. Two alternatives were then proposed, with the first accepted. The first alternative was a ship of 7,580 tons with 96 VLS cells, integrated electric drive, three LM-2500 gas turbines with RACER technology, and two 16-cylinder diesel engines. Length conflicts soon became apparent as the addition of a helicopter landing pad dictated a 466-foot hull.

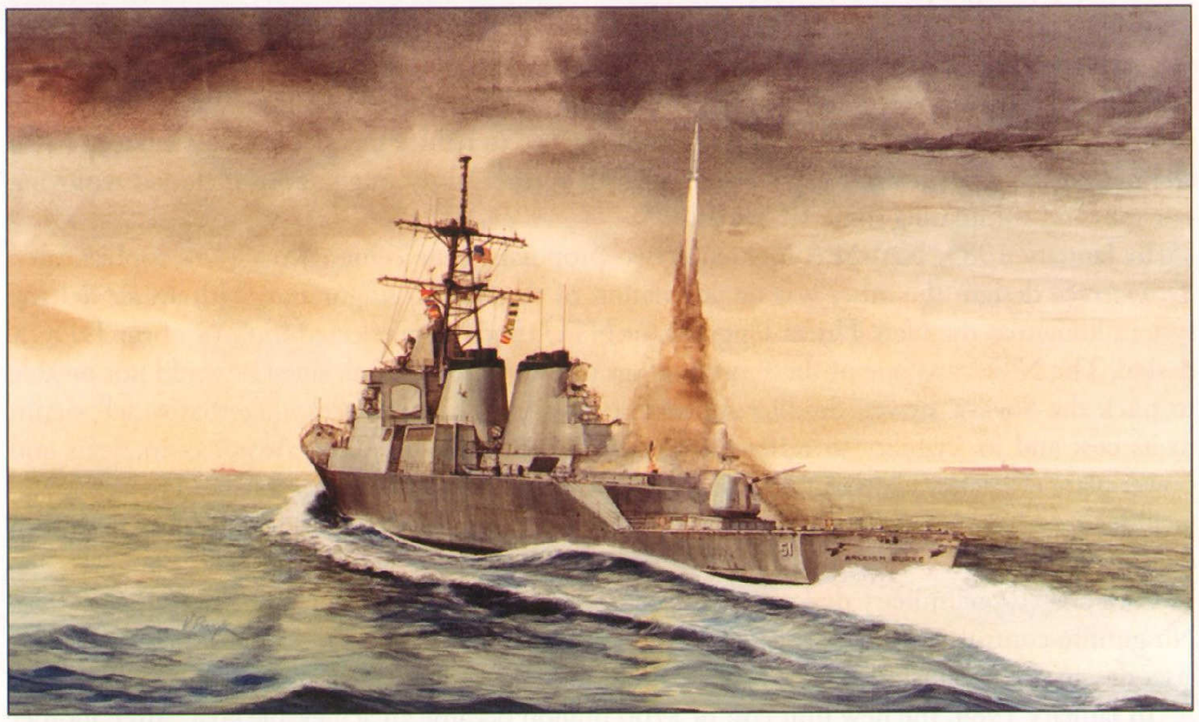
New BGM-109 Tomahawk Land Attack Missiles (TLAMs) would turn the ships into strike platforms that could attack targets far inland. Older classes, such as *Spruance* and *Virginia*, were outfitted with Tomahawks, but since the new weapons were larger, not many could not be carried. If launched at sea, no missiles would be available for a second attack. The new ship would carry enough TLAMs and VLS modules for a meaningful offensive capability.

By now the Reagan Administration was in power, with new attitudes toward procurement, tackling more aggressively the challenges of the Cold War by proposing a 600-ship Navy. Aegis was now firmly accepted as the standard for primary radar equipment on DDGX, along with the Standard Missile in its improved versions. Frigate production lost emphasis to cruisers and destroyers, now seen as essential components of surface forces.

Changes to the basic design were offered as some of the concepts (RACER and electric drive) were deemed impractical and overly complicated, raising concerns of lengthened development. A new review was convened by the CNO that eliminated all the innovative concepts and stated that overall dependability would be paramount. More missiles were included as well as four LM-2500 power plants, with two gas turbines driving each propeller shaft. This resulted in greater size and



This model shows *Arleigh Burke* as she was envisioned in 1985, with squared-off deckhouses, her gun forward, and her SPG-62s in their final configuration. Her lattice-style vertical mast was later replaced with a tripod design, with composite structures angled aft to reduce radar signature. (*RCA*)



In this painting, *Arleigh Burke* fires a Standard Missile from its aft VLS. The aft-mounted 5-inch gun and large electro-optical director just below the aft-facing SPG-62 were not incorporated in the final design. (*Vince Piecyk/NAVSEA*)

weight. The cost ceiling per unit was increased from $550 million to between $600 million and $650 million per unit. With an added towed-array sonar, habitability changes, greater range, and alterations to increase the power of the Aegis radars, displacement increased to 8,700 tons.

The Office of the Chief of Naval Operations (OpNav) authorized a top-level requirement for the new ship in June 1981, emphasizing combat capability and survivability. Further design progress and reviews in 1982 included increased priority on improving habitability and growth options and decreased priority on energy conservation. Light Airborne Multi-Purpose System III (LAMPS) equipment was added to provide access to the SH-60B information data link. The 5-inch gun was relocated from aft to forward. Weight was saved by using lightweight armor and hull construction techniques.

While design work was moving forward, the Falklands War broke out. After the conflict, Secretary of the Navy John Lehman requested information on lessons learned that could be applied to DDGX. In October 1982, one recommendation put forth was for all-steel construction. Others included protection from the effects of a nuclear explosion by hardening critical electrical components against electromagnetic pulses. The filtering of the ship's air against nuclear, biological, and chemical (NBC) agents and the use of airtight hatches and positive pressure was known as the Collective Protection System (CPS). Separating critical systems throughout the interior decreased the chances of one hit taking out all vital components of combat control. Radar cross-section (RCS) alterations, such as sloping the hull sides and exterior surfaces, and the addition of mesh screens in glass to prevent radar wave penetration reduced radar reflections.

The hull was flared along the sides to accommodate the increased beam (with the added benefit of reducing RCS) with a forward hull in a "V" shaped instead of a "U" shape. The transom was wide and flared at the sides. A stern wedge was designed into the hull profile to improve handling and stability at high speeds.

At the end of 1982, a final design was ready. It was 466 feet long with a 61-foot beam. Its speed was estimated at just over 31 knots, with a range of up to 6,000 nautical miles. The cost per unit after initial production was projected at $744 million from the fifth ship onward. In January 1983, the proposal was rejected, with recommendations given to reduce the cost to $650 million. As an alternative, the *Ticonderoga* design was offered for further study. Suggestions included removing one gun and eliminating some VLS cells.

In January 1983, NAVSEA looked at two proposals. One centered on a less sophisticated *Ticonderoga* design; the other was an adaptation of the *Kidd* configuration with an air defense system known as the New Threat Upgrade, or NTU. Both were rejected in favor of the DDGX design. The NTU was one of the shortcomings of the *Kidd* proposal, since it would not be able to track the Soviets' newer, deadlier supersonic missiles. The *Ticonderoga* alternative fell victim to its cost and its inability to carry Tomahawks in sufficient numbers. Advances in Aegis and power plant efficiency allowed the DDGX plan to move ahead in February 1983. The helicopter facilities remained intact as the RACER concept proved unworkable and was eliminated from consideration.

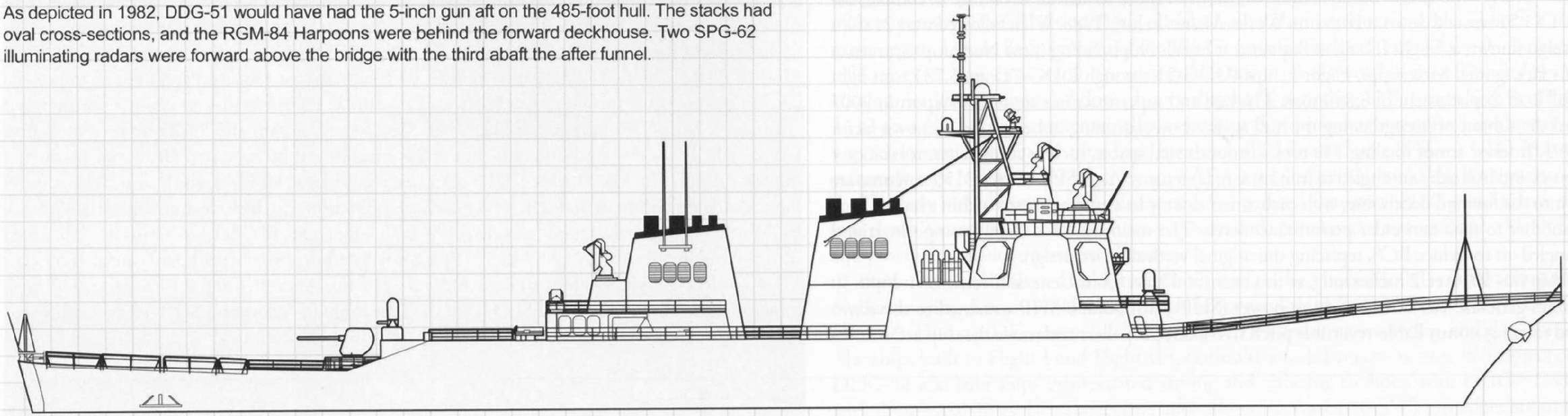
An updated preliminary design was agreed upon, and the contract phase began in May 1983. No gunfire-control radar was installed, and neither the 5-inch laser-guided shell nor the Seafire laser designator was included. The beam was cut to 59 feet.

In January 1984, the new unit cost of $700 million became an achievable goal. After another design proposal was turned down, at last the first ship of the new DDGX design, *Arleigh Burke*, was placed in Fiscal Year (FY) 1985 budget.

Donald Cook (DDG-75) cruises in the Mediterranean Sea. Her armament includes a 5-inch gun, with the Mk 41 VLS forward battery just aft of the gun. The forward VLS held 29 rounds. In front of the bridge is the forward Mk 15 Phalanx Close In Weapon System (CIWS). Flanking the bridge port and starboard are the forward-facing 12-foot hexagonal arrays of the SPY-1D Aegis system anti-air warfare radar. Facing outboard of the SPY-1D sets are the SLQ-32(V)3 active electronic warfare (EW) jammers. (*U.S. Navy Photographer's Mate 1st Class Michael W. Pendergrass*)

DDG-51 as depicted in 1982

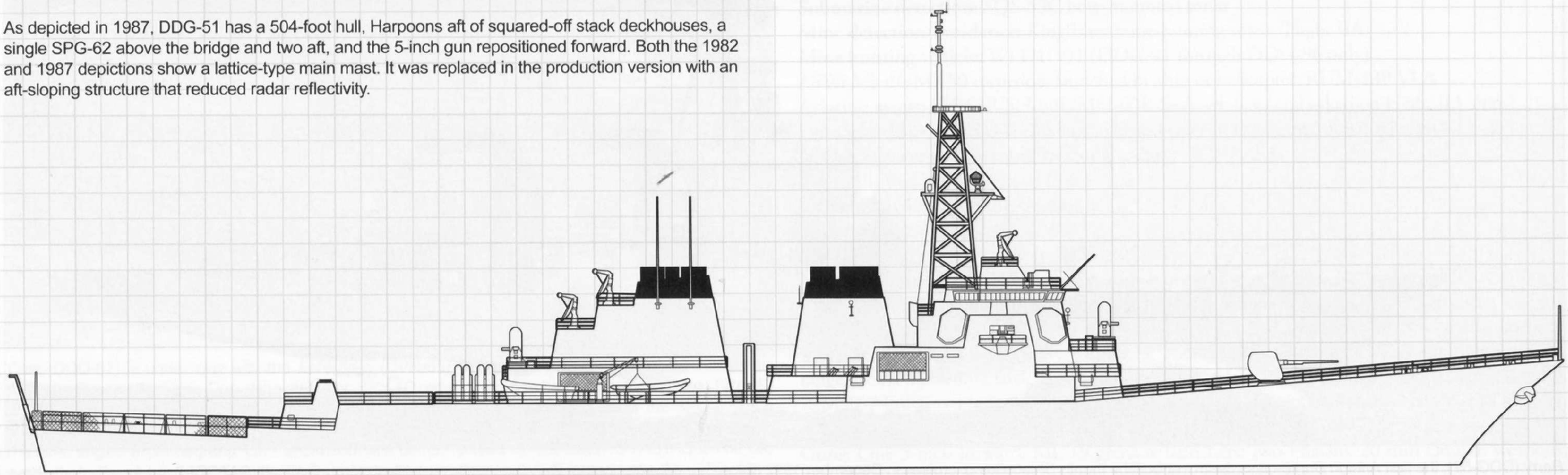
As depicted in 1982, DDG-51 would have had the 5-inch gun aft on the 485-foot hull. The stacks had oval cross-sections, and the RGM-84 Harpoons were behind the forward deckhouse. Two SPG-62 illuminating radars were forward above the bridge with the third abaft the after funnel.



(*based on original line drawing by A.D. Baker III*)

DDG-51 as depicted in 1987

As depicted in 1987, DDG-51 has a 504-foot hull, Harpoons aft of squared-off stack deckhouses, a single SPG-62 above the bridge and two aft, and the 5-inch gun repositioned forward. Both the 1982 and 1987 depictions show a lattice-type main mast. It was replaced in the production version with an aft-sloping structure that reduced radar reflectivity.



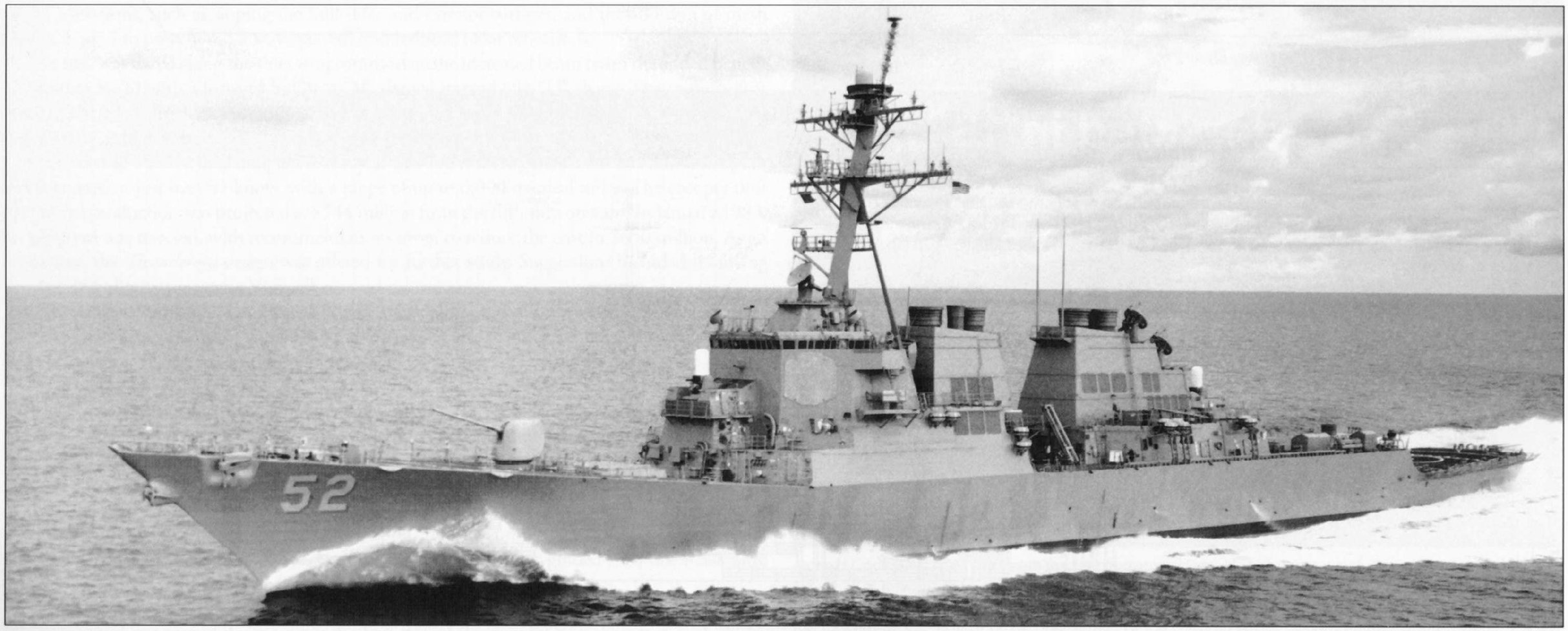
(*based on original line drawing by A.D. Baker III*)

Arleigh Burke in detail

Named after Adm. Arleigh Burke, the legendary destroyer skipper of World War II who earned the nickname "Thirty One Knot" Burke because of his use of speed to tactical advantage in combat, the keel of DDG-51 was laid down at Bath Iron Works, Maine, in June 1988. What followed were 21 ships of the design known as Flight I, built at Bath and at Ingalls Shipbuilding (now Northrop Grumman Corp.) in Pascagoula, Mississippi. Flight I ships (DDG-51 through DDG-71) are 6,731 tons light with a full load displacement of 8,850 tons. The hull and superstructures are steel. A report in 2007 addressed the subject of strengthening the hull against bow slamming in heavy seas, a known factor since 1993. Interior armor totaling 130 tons surrounds vital spaces, such as combat control stations. Deckhouses and hull sides are angled to minimize radar returns. Aegis SPY-1D AS-3159 antennas are secured into the forward deckhouse, with each antenna array level and square to within a half an inch of one another to maintain radar performance levels. The main mast is a largely composite tripod design angled aft to reduce RCS, replacing the original vertical lattice design.

The ship was 504 feet, 2 inches long, with a beam of 67 feet. Four General Electric LM-2500-30 gas turbines generate 105,000 shaft horsepower (SHP) with 90,000 SHP sustained to drive two outboard turning, controllable-reversible pitch five-blade propellers and move the ship at 31 knots or more. During sea trials, DDG-51 was able to maintain 30 knots in a 60-knot gale with 35-foot seas, proving the capabilities of a broad hull. Electric power (7,500 kW) is provided by three Allison 501-K34 gas turbines. The ship's range at 20 knots is 4,400 nautical miles.

Its armament is extensive and includes a Mk 45 5-inch dual-purpose gun forward, two Mk 15 Mod 12 Phalanx block 1 A/B 20 mm rotary CIWS cannons (one forward and one aft) to provide defense against cruise missiles, small boats, and aircraft. The ship also has two 25 mm Bushmaster chain guns, Mk 19 40 mm grenade launchers, and four 12.7 mm and 7.62 mm machine guns. Up to eight RGM-84 Harpoon anti-ship cruise missiles can be mounted aft in two quadruple canister groups. The Mk 41 Mod 0 VLS is located forward and aft inside the hull and contains 29 rounds forward and 61 rounds aft. VLS missile combinations can include anti-ship or land-attack BGM-109 Tomahawk cruise missiles, SM-2 missiles, or RUM-139 Vertically Launched Anti-Submarine Rockets (VLA). Mk 32 triple torpedo tubes port and starboard can launch either Mk 46 or Mk 50 types with pneumatic pressure. The bow-mounted sonar is the SQS-53C with mine-avoidance capability. Dual SLQ-25A(V) Nixie torpedo decoys and SQR-19 Tactical Towed Array Sonar System (TACTASS) can be streamed from the transom.



Barry (DDG-52), the first *Arleigh Burke*-class destroyer built by Ingalls Shipbuilding, cruises in December 1992 before her commissioning. Only the WSC-3 satellite communications (SATCOM) antenna is seen above the bridge windows, and the mast has early electronics fit with the LAMPS data link in white radome. (*Northrop Grumman photo*)

Cole (DDG-67) is under way with the *Enterprise* (CVN-65) Carrier Strike Group (CSG) in the Atlantic Ocean in September 2003. One of the aft-facing SPY-1D radar arrays can be seen, along with two SPG-62 target-illuminating radars atop the aft deckhouse aft of the exhaust stacks. Just below the SPG-62s is a Mk 15 CIWS. Below the CIWS is the Mk 141 shock hardened stand-alone launchers for eight Harpoon missiles, angled at 35 degrees. On the transom is a center fairlead for the SQR-19 TACTASS. The two ports at starboard accommodate the SLQ-25 Nixie decoys used to defeat torpedo attacks. (*U.S. Navy Photographer's Mate 2nd Class Douglas M. Pearlman*)

For electronic warfare equipment, the ship carries versions of the SLQ-32 active EW jammer and Mk 36 Super Rapid Bloom Offboard Chaff (SRBOC) launchers. Data link capability with the SH-60B LAMPS helicopter is located high on the mainmast in an enclosed radome; the antenna is designated AS-3274. The URN-25 tactical air navigation (TACAN) antenna AS-3240 is at the top of the mainmast. The SPS-64 and Decca Bridge Master E are used for navigation. The SPS-67 is used as a navigation radar. Early versions of the SPS-67 surface search unit were of the (V)3 curved lattice reflector type; later units are slotted waveguide variants (V)4, which now outfit all ships. Satellite communications are provided through several systems, including SSR-1 to receive fleet broadcasts 24 hours a day. Sea Tel commercial telephone equipment provides reception while the ship is under way. Communication in the ultra high frequency (UHF) band uses WSC-3; USC-38 is used for extremely high frequency (EHF) coverage. SAT-2 is used to send infrared blinker signals.

The crew includes around 22 officers and 315 enlisted personnel. NBC protection is designed into the ships with an exterior washdown system and some interior spaces fitted with air filtration equipment and positive pressure systems.

Equipment added since the ships were built include the Mk 46 Mod 0 optronic director, Mk 53 Nulka hovering decoys, WSC-6 super high frequency (SHF) SATCOM, and the SRS-1 Combat Direction Finding (DF) system (excluding Flight I) for detecting, analyzing, and classifying signals. The ships built to Flight I and Flight II specifications lack hangars to store helicopters onboard. DDG-52 and later ships incorporated arming and refueling facilities, with DDG-51 retrofitted with those capabilities. Nine helicopter anti-submarine warfare (ASW) torpedoes are stored near the aft landing pad. Two rigid-hull inflatable boats (RHIBs) are available for ship-to-ship or ship-to-shore liaison duties or for visit, board, search, and seizure (VBSS) parties. Life rafts include 15 25-man self-inflating units in canisters along the superstructure sides.

DDG-51 class ships have the following equipment and capabilities:

Electronic intelligence gathering: SRS-1 combat direction finder (Flights II and IIA)
Submarine detection: SQS-53C bow-mounted sonar
Mine detection/avoidance: Kingfisher mine-hunting sonar (Flight IIA)
Mine hunting vehicle: WLD1(V)1 (DDG-91 through DDG-96 only)
ASW: Mk 46/Mk 50 torpedoes launched by ship or helicopter; RUM-139 VLA
Aviation assets: SH-60B/SH-60F/MH-60R Seahawk (two embarked on Flight IIA ships)
Unmanned aircraft: RQ-8 Fire Scout vertical take-off unmanned aerial vehicle (VTUAV)
Long-range surveillance and tracking radar: SPY-1D Aegis
Target illumination: Three SPG-62
Navigation: SPS-64/Bridge Master E
Surface search: SPS-67
SATCOM: SSR-1, receive only; WSC-3, UHF; USC-38, EHF; WSC-6, SHF
Data links: LAMPS, helicopter to ship; cooperative engagement capability (CEC), target engagement; Joint Tactical Information Distribution System (JTIDS), force multiplier
Electronic warfare: SLQ-32 active jammer; Mk 53 Nulka decoy; Mk 36 SRBOC chaff launcher
Weapons: Mk 46/Mk 50 ASW torpedoes; Standard Missiles SM-2/SM-3, air intercept long range; BGM-109 Tomahawk, land attack; RGM-84 Harpoon anti-ship missiles (Flight I/II only); RIM-162 Enhanced Sea Sparrow Missiles (ESSM), air intercept short range; AGM-114 Hellfire, helicopter-launched weapon; Extended Range Guided Munition (ERGM)
Guns: One 5-inch forward; Mk 19 grenade launchers; two Phalanx 20 mm close-in weapons; 25 mm Bushmaster guns; 12.7 mm and 7.62 mm machine guns.

In the ballistic missile defense role, a series of successful tests resulted in an upgrade of the Aegis radars on DDG-54, DDG-63, and DDG-73 to detect, track, and illuminate ballistic missiles. In order to intercept such targets during flight, SM-3 missiles were developed, adding a kinetic warhead integrated with an infrared seeker.

DDG-51 was ordered in February 1985, DDG-52 in May 1987, and DDG-53 in August 1987. Five more (DDG-54 through DDG-58) were ordered in December 1988. DDG-59 through DDG-63 were funded in February 1990. DDG-64 through DDG-67 were ordered in January 1991. DDG-68 through DDG-72 were ordered in April 1992. DDG-73 through DDG-76 were bought in January 1993 for $3.25 billion. DDG-77, DDG-78, and DDG-79 cost $2.9 billion in 1994.

All ships in this class are named after naval personnel. DDG-70 is named after a woman, Rear Adm. Grace Hopper. DDG-81 is named after a foreign head of state who also served as First Lord of the Admiralty in the Royal Navy, Winston S. Churchill.

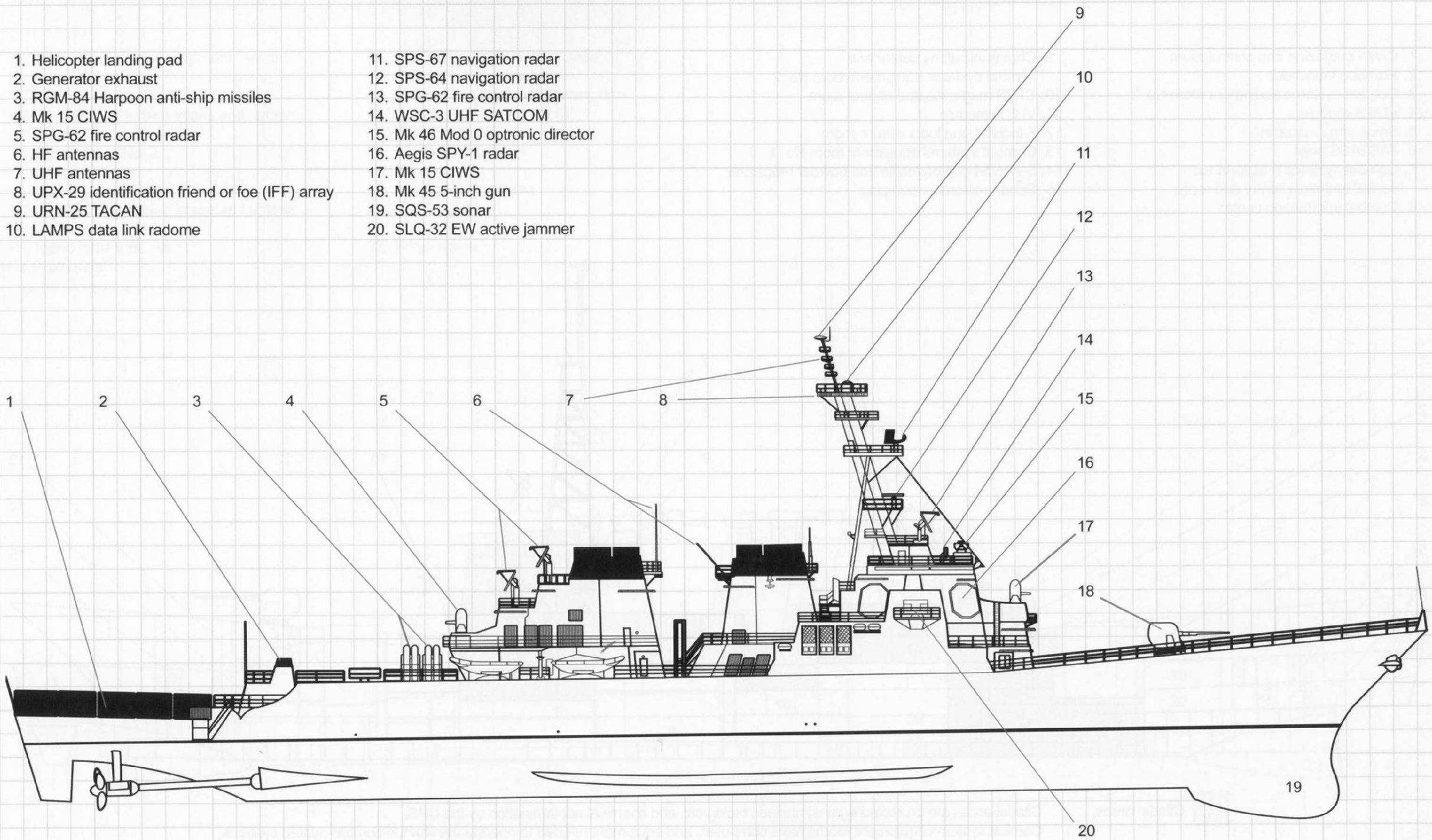
DDG-68 is named after the five Sullivan brothers who died when the ship on which they were serving, *Juneau* (CL-52), was sunk during the Naval Battle of Guadalcanal in World War II. DDG-63 is named after Robert D. Stethem, a Navy diver killed by terrorists during the hijacking of TWA flight 847 in June 1985. DDG-99 honors the first admiral in the U.S. Navy, David Farragut, famous for giving the command "Damn the torpedoes, full steam ahead!" during the Battle of Mobile Bay on 5 August 1864.

In the Mediterranean Sea, *Barry* keeps her station in less than ideal surface conditions while assigned to the *Harry S. Truman* (CVN-75) CSG in April 2005. White radomes atop the bridge house USC-38 EHF SATCOM antennas. (*U.S. Navy Photographer's Mate Airman Philip V. Morrill*)

*Decatur (*DDG-73) executes a hairpin turn after passing by *Ronald Reagan* (CVN-76). Visible are one of the aft-facing SPY-1D radar antennas, a Mk 15 Phalanx CIWS under the SPG-62 target illuminating radar dish, and canisters for RGM-84 Harpoon surface-to-surface missiles under the CIWS. (*U.S. Navy Mass Communications Specialist Seaman Gary Prill*)

DDG-51 as built

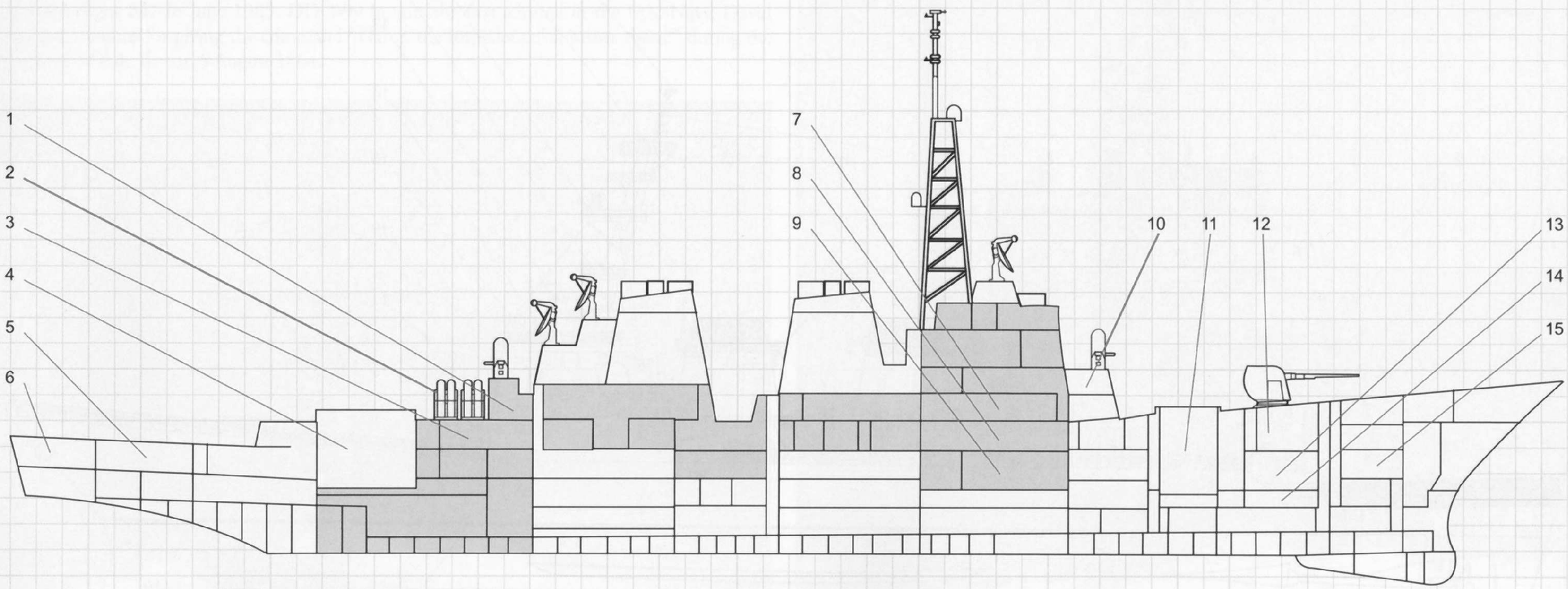
1. Helicopter landing pad
2. Generator exhaust
3. RGM-84 Harpoon anti-ship missiles
4. Mk 15 CIWS
5. SPG-62 fire control radar
6. HF antennas
7. UHF antennas
8. UPX-29 identification friend or foe (IFF) array
9. URN-25 TACAN
10. LAMPS data link radome
11. SPS-67 navigation radar
12. SPS-64 navigation radar
13. SPG-62 fire control radar
14. WSC-3 UHF SATCOM
15. Mk 46 Mod 0 optronic director
16. Aegis SPY-1 radar
17. Mk 15 CIWS
18. Mk 45 5-inch gun
19. SQS-53 sonar
20. SLQ-32 EW active jammer



(*based on original line drawing by A.D. Baker III*)

Arleigh Burke class vital spaces

1. CIWS magazine and control room
2. Harpoon launchers
3. Combat systems equipment room No. 3
4. VLS B-module
5. Small arms magazine
6. TACTASS hoist
7. Combat systems maintenance central technical library and repair
8. Combat information center
9. Communications center and combat systems equipment room No. 2
10. CIWS magazine and control room
11. VLS A-module
12. 5-inch/54 gun loader drum room
13. Combat systems equipment room No. 1
14. 5-inch/54 gun projectile and powder magazine
15. Sonar equipment complex



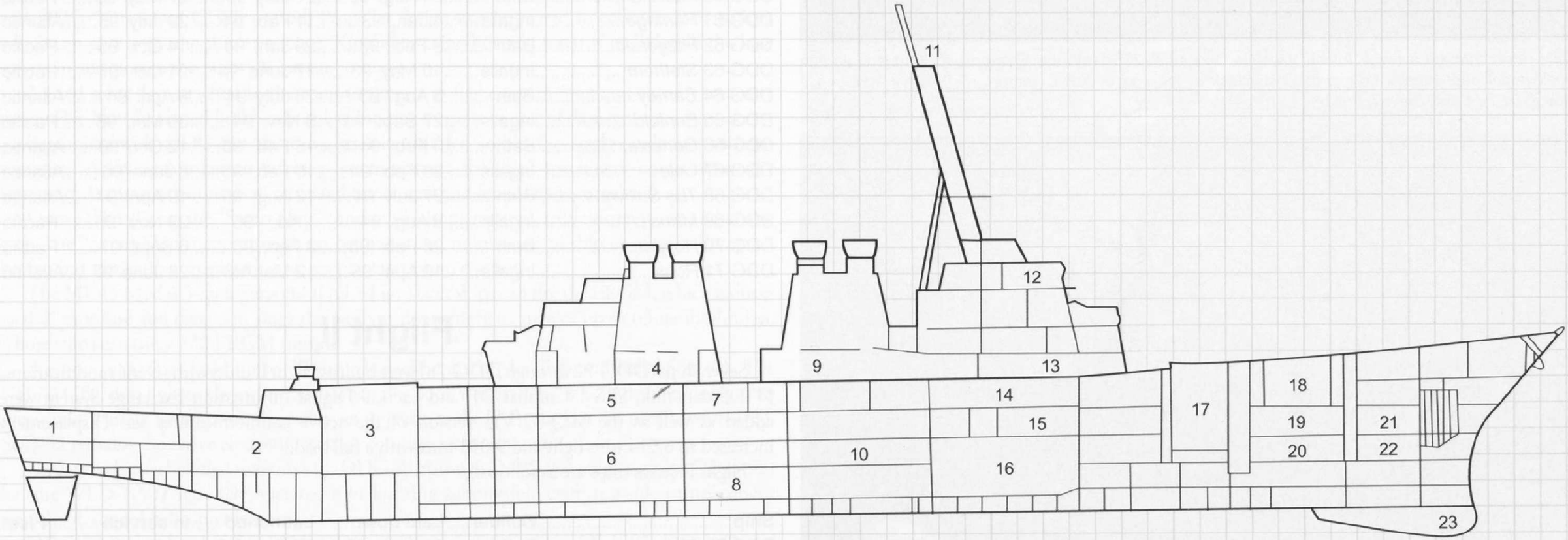
Citadel areas.

Citadel areas are protected against nuclear, biological, and chemical contamination by the CPS.
Combat systems equipment rooms have computers and equipment needed to operate the various combat-related systems.

(*based on U.S. Navy drawing*)

DDG-51 cutaway diagram

1. Towed array sonar equipment section
2. Generator room
3. VLS B-module
4. LM-2500 gas turbine intake and uptake
5. Damage control central
6. Engine room No. 2
7. Crew mess
8. Auxiliary machine room No. 2
9. LM-2500 gas turbine intake and uptake
10. Engine room No. 1
11. Tripod mast tilted aft
12. Pilothouse
13. Combat systems maintenance
14. Combat information center
15. Combat systems equipment room
16. Auxiliary machine room No. 1
17. VLS A-module
18. 5-inch gun loader
19. Sonar control
20. 5-inch gun magazine
21. Sonar
22. Sonar
23. Sonar dome



(based on line drawing from "U.S. Destroyers: An Illustrated Design History," Revised Edition, 2004, by Dr. Norman Friedman)

Cole plows through a rough Atlantic swell in December 2003 with the *Enterprise* CSG during its first deployment after repairs from a terrorist attack in the port of Aden, Yemen. (*U.S. Navy Intelligence Specialist 1st Class Brian T. Smith*)

After passing *Carl Vinson* (CVN-70), *Lassen* (DDG-82) performs an emergency breakaway maneuver in the Philippine Sea. Agility such as this is a testament to crew skill and to those who build durable seagoing combat vessels. (*U.S. Navy Photographer's Mate Airman Dustin Howell*)

Flight I

The 21 Flight I series ships were built at General Dynamics Bath Iron Works in Bath, Maine, and Northrop Grumman Ship Systems, Ingalls Division, in Pascagoula, Mississippi.

Flight I ships are as follows:

Ship	Builder	Laid down	Launched	In service	Fleet
DDG-51 *Arleigh Burke*	Bath	6 Dec. '88	16 Sept. '89	4 July '91	Atlantic
DDG-52 *Barry*	Ingalls	29 Feb. '90	10 May '91	12 Dec. '92	Atlantic
DDG-53 *John Paul Jones*	Bath	8 Aug. '90	26 Oct. '91	18 Dec. '93	Pacific
DDG-54 *Curtis Wilbur*	Bath	12 Mar. '91	16 May '92	19 Mar. '94	Pacific
DDG-55 *Stout*	Ingalls	13 Sept. '91	16 Oct. '92	13 Aug. '94	Atlantic
DDG-56 *John S. McCain*	Bath	3 Sept. '91	26 Sept. '92	2 July '94	Pacific
DDG-57 *Mitscher*	Ingalls	12 Feb. '92	7 May '93	10 Dec. '94	Atlantic
DDG-58 *Laboon*	Bath	23 Mar. '92	20 Feb. '93	18 Mar. '95	Atlantic
DDG-59 *Russell*	Ingalls	27 July '92	20 Oct. '93	20 May '95	Pacific
DDG-60 *Paul Hamilton*	Bath	24 Aug. '92	27 July '93	27 May '95	Pacific
DDG-61 *Ramage*	Ingalls	4 Jan. '93	11 Feb. '94	22 July '95	Atlantic
DDG-62 *Fitzgerald*	Bath	9 Feb. '93	29 Jan. '94	14 Oct. '95	Pacific
DDG-63 *Stethem*	Ingalls	10 May '93	17 June '94	21 Oct. '95	Pacific
DDG-64 *Carney*	Bath	3 Aug. '93	23 July '94	8 April '96	Atlantic
DDG-65 *Benfold*	Ingalls	27 Sept. '93	5 Nov. '94	30 Mar. '96	Pacific
DDG-66 *Gonzalez*	Bath	3 Feb. '94	18 Feb. '95	12 Oct. '96	Atlantic
DDG-67 *Cole*	Ingalls	28 Feb. '94	10 Feb. '95	8 June '96	Atlantic
DDG-68 *The Sullivans*	Bath	27 July '94	12 Aug. '95	19 April '97	Atlantic
DDG-69 *Milius*	Ingalls	8 Aug. '94	1 Aug. '95	23 Nov. '96	Pacific
DDG-70 *Hopper*	Bath	26 Feb. '95	3 Feb. '96	6 Sept. '97	Pacific
DDG-71 *Ross*	Ingalls	10 April '95	12 Mar. '96	28 June '97	Atlantic

Flight II

Seven ships (DDG-72 through DDG-78) were built as Flight II units with several modifications. JTIDS data-link, SRS-1 Combat DF, and Tactical Digital Information Exchange System were added as well as the SLQ-32(V)3 version of the active countermeasures set. Displacement increased to 6,914 tons light and 9,033 tons with a full load.

Flight II series ships are as follows:

Ship	Builder	Laid down	Launched	In service	Fleet
DDG-72 *Mahan*	Bath	18 June '95	29 June '96	14 Feb. '98	Atlantic
DDG-73 *Decatur*	Bath	15 Jan. '96	9 Nov. '96	29 Aug. '98	Pacific
DDG-74 *McFaul*	Ingalls	12 Feb. '96	11 Jan. '97	17 April '98	Atlantic
DDG-75 *Donald Cook*	Bath	7 July '96	3 May '97	4 Dec. '98	Atlantic
DDG-76 *Higgins*	Bath	17 Nov. '96	4 Oct. '97	24 April '99	Atlantic
DDG-77 *O'Kane*	Bath	11 May '97	28 Mar. '98	23 Oct. '99	Pacific
DDG-78 *Porter*	Ingalls	2 Dec. '96	15 Oct. '97	20 Mar. '99	Atlantic

Flight IIA

Production shifted to Flight IIA with DDG-79, where length was increased 5 feet to 509 feet overall. To avoid blocked coverage because of helicopter hangars, the aft-facing SPY-1D arrays were raised 7 feet. Most importantly, two helicopter hangars were incorporated into the improved design; it was found from Gulf War experience that having a dedicated helicopter aboard aided ship searches and anti-shipping attacks. With this enhancement, one ASW helicopter and one conventionally armed helicopter could be carried.

For recovering helicopters in rough seas (up to sea state 5) the recovery, assist, secure, and traverse (RAST) system was installed.

The RQ-8 Fire Scout remotely piloted helicopter drone will eventually be carried by the ships. This pilotless helicopter has demonstrated the ability to fire unguided 70 mm folding-fin aerial rockets and will have a suite of sensors to observe, track, and engage targets. At-sea reloading of VLS cells was deleted on all ships. The elimination of this ability meant six more rounds could be carried.

RIM-162 ESSM surface-to-air missiles (SAMs) are loaded four to a cell on ships without Phalanx CIWS. ESSM was to replace Phalanx, but because of delays, DDG-81 through DDG-84 and DDG-94 received CIWS instead. Propeller design was improved to counteract cavitation, which can give away the ship's presence. Kingfisher mine-hunting sonar is included in the bow sphere in addition to the SQS-53C sonar.

A fixed stern flap attached to the transom improves fuel consumption and thereby increases range. Five blast-hardened bulkheads isolate interior sections in case of damage.

Beginning with DDG-89, the exhausts were hidden inside the stacks, reducing infrared signature. A Prairie Masker air-bubbler system reduces the ship's machinery noises below the waterline. Accommodations were increased for aircrew and female crew members.

From DDG-83 on, the "Smart Ship" concept was implemented, reducing crew size and saving cost. The "Smart Ship" concept relies on computerized monitoring of ship operations, integrity, bridge and navigation operations, and propulsion system control.

The Mk 45 Mod 4 5-inch gun on DDG-81 and later ships can fire the ERGM, which reduces tactical exposure and detection since the weapon can achieve a range of up to 63 nautical miles. Those ships can carry 232 ERGM rounds.

Weapon magazines hold up to 40 torpedoes (Mk 46/50) for ship and helicopter use. The USG-2 CEC data link was being installed when this book was written. SLY-2 Advanced Integrated Electronic Warfare System was planned as an upgrade to the EW suite but has now been shelved. SLQ-32 remains the active electronic warfare countermeasure system.

Of the six ships scheduled to receive it, (DDG-91 through DDG-96) only *Momsen* (DDG-92) has the WLD-1(V)1 remotely operated minehunting submersible craft in a side compartment near the starboard helicopter hangar.

DDG-79 was ordered in FY 1994; DDG-80 through DDG-82 in FY 1995; DDG-83 and DDG-84 in FY 1996; DDG-85 through DDG-88 in FY 1997; DDG-89 through DDG-92 in FY 1998; DDG-93 through DDG-95 in FY 1999; DDG-96 through DDG-98 in FY 2000; DDG-99 through DDG-101 in FY 2001; DDG-102 through DDG-104 in FY 2002; and DDG-105 through DDG-107 in FY 2003. Each was budgeted at $1.2 billion. DDG-108 through DDG-110 were ordered in FY 2004, and DDG-111 and DDG-112 were ordered in FY 2005.

Flight IIA *Arleigh Burke*-class destroyer *Nitze* (DDG-94) sails up the Hudson River at the beginning of Fleet Week New York City 2006. (*U.S. Navy Photographer's Mate Christopher Newsome*)

Ships of the Flight IIA series so far include:

Ship	Builder	Laid down	Launched	In service	Fleet
DDG-79 *Oscar Austin*	Bath	9 Oct. '97	7 Nov. '98	19 Aug. '00	Atlantic
DDG-80 *Roosevelt*	Ingalls	15 Dec. '97	10 Jan. '99	14 Oct. '00	Atlantic
DDG-81 *Winston S. Churchill*	Bath	7 May '98	17 April '99	10 Mar. '01	Atlantic
DDG-82 *Lassen*	Ingalls	24 Aug. '98	15 Oct. '99	21 April '01	Pacific
DDG-83 *Howard*	Bath	9 Dec. '98	20 Nov. '99	20 Oct. '01	Pacific
DDG-84 *Bulkeley*	Ingalls	10 May '99	21 June '00	8 Dec. '01	Atlantic
DDG-85 *McCampbell*	Bath	15 July '99	2 July '00	17 Aug. '02	Pacific
DDG-86 *Shoup*	Ingalls	13 Dec. '99	22 Nov. '00	22 June '02	Pacific
DDG-87 *Mason*	Bath	20 Jan. '00	23 June '01	12 April '03	Atlantic
DDG-88 *Preble*	Ingalls	22 June '00	1 June '01	19 Nov. '02	Pacific
DDG-89 *Mustin*	Ingalls	15 Jan. '01	12 Dec. '01	26 July '03	Pacific
DDG-90 *Chafee*	Bath	12 April '01	2 Nov. '02	18 Oct. '03	Pacific
DDG-91 *Pinckney*	Ingalls	16 July '01	26 June '02	19 May '04	Pacific
DDG-92 *Momsen*	Bath	25 Nov. '01	19 July '03	28 Aug. '04	Pacific
DDG-93 *Chung-Hoon*	Ingalls	14 Jan. '02	11 Dec. '02	18 Sept. '04	Pacific
DDG-94 *Nitze*	Bath	20 Sept. '02	3 April '04	5 Mar. '05	Atlantic
DDG-95 *James E. Williams*	Ingalls	15 July '02	25 June '03	11 Dec. '04	Atlantic
DDG-96 *Bainbridge*	Bath	7 May '03	30 Oct. '04	12 Nov. '05	Atlantic
DDG-97 *Halsey*	Ingalls	24 Feb. '03	9 Jan. '04	30 July '05	Pacific
DDG-98 *Forrest Sherman*	Ingalls	7 Aug. '03	30 June '04	28 Jan. '06	Atlantic
DDG-99 *Farragut*	Bath	7 Jan. '04	9 July '05	4 May '06	Atlantic
DDG-100 *Kidd*	Ingalls	1 Mar. '04	15 Dec. '04	30 May '07	Pacific
DDG-101 *Gridley*	Bath	30 July '04	28 Dec. '05	2 Oct. '07	Pacific
DDG-102 *Sampson*	Ingalls	14 Mar. '05	17 Sept. '06	delivered 25 May '07	
DDG-103 *Truxton*	Ingalls	11 April '05	17 April '07		
DDG-104 *Sterett*	Bath	17 Nov. '05	20 May '07		
DDG-105 *Dewey*	Ingalls	4 Oct. '06			
DDG-106 *Stockdale*	Bath	10 Aug. '06			
DDG-107 *Gravely*	Ingalls				
DDG-108 *Wayne E. Meyer*	Bath				
DDG-109 *Jason Dunham*	Bath				
DDG-110 *William P. Lawrence*	Ingalls				
DDG-111 *Spruance*	Bath				
DDG-112	Bath				

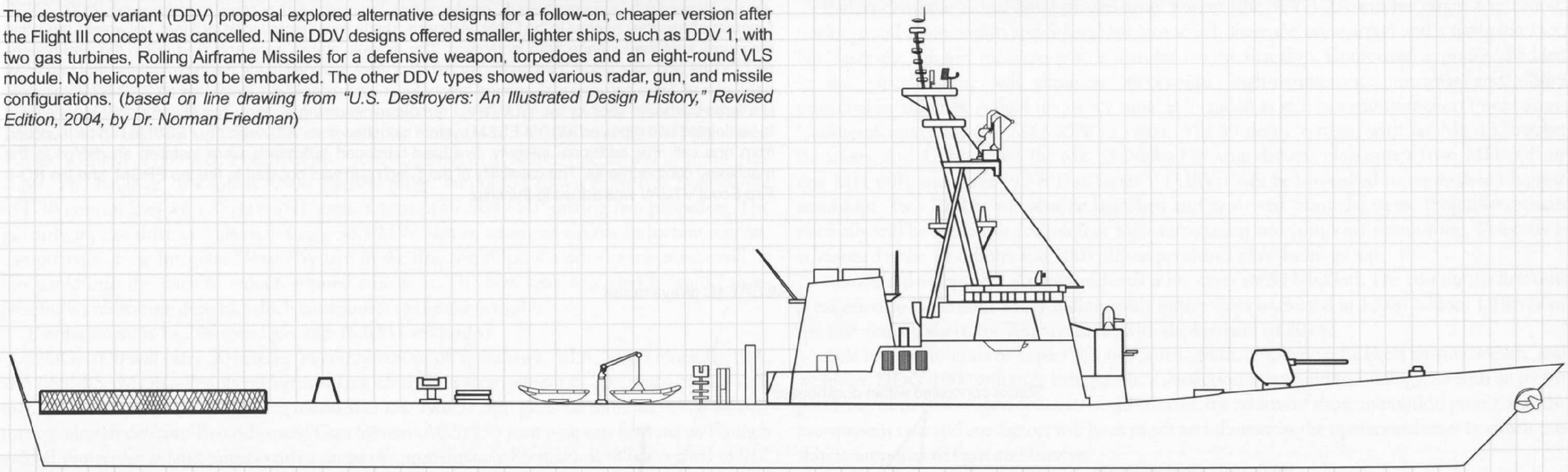
Flight III

In April 1988, OpNav ordered a Flight III design review to investigate major alterations to the *Arleigh Burke* design. The most obvious alterations were a 40-foot hull extension, dual helicopter hangars, recessed torpedo tubes into the hull sides, and two VLS cells of 64 missiles each. The final design had a hull length of 544.5 feet and a beam of 59.5 feet. Tonnage would have been 7,962 tons light and 10,722 tons loaded. This concept was not pursued further because of the perceived cost.

The Flight IIA destroyer *McCampbell* (DDG-85) executes a high-speed maneuver during a sea power demonstration while on deployment in support of the Global War on Terrorism and maritime security operations in the Pacific Ocean. (*U.S. Navy Mass Communications Specialist Kathleen Gorby*)

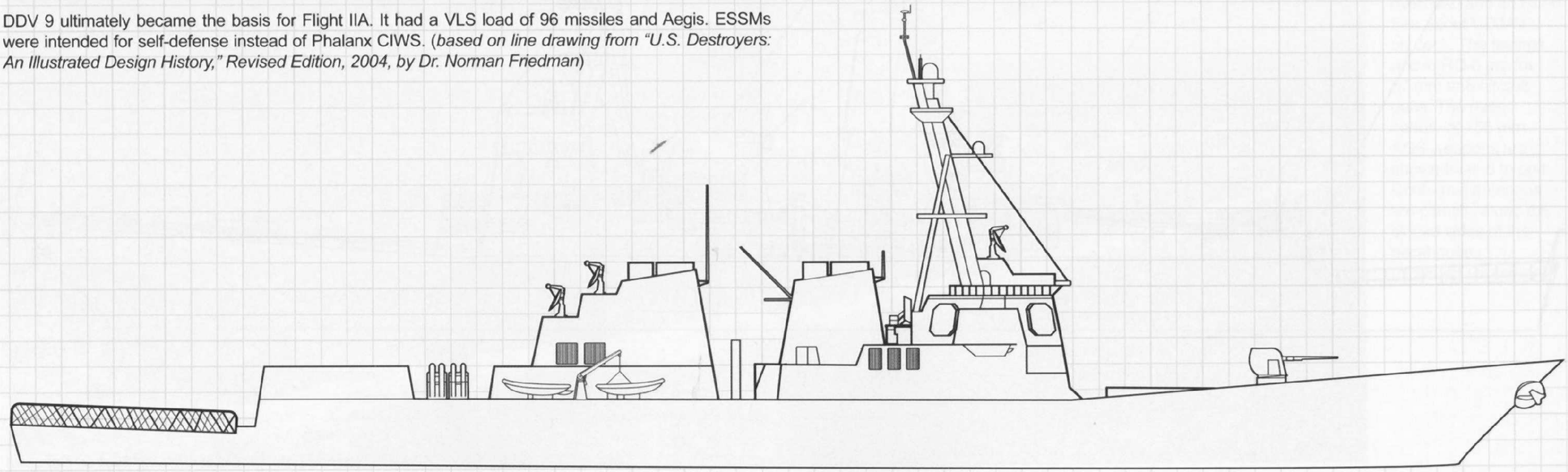
Proposed destroyer variant 1

The destroyer variant (DDV) proposal explored alternative designs for a follow-on, cheaper version after the Flight III concept was cancelled. Nine DDV designs offered smaller, lighter ships, such as DDV 1, with two gas turbines, Rolling Airframe Missiles for a defensive weapon, torpedoes and an eight-round VLS module. No helicopter was to be embarked. The other DDV types showed various radar, gun, and missile configurations. (*based on line drawing from "U.S. Destroyers: An Illustrated Design History," Revised Edition, 2004, by Dr. Norman Friedman*)



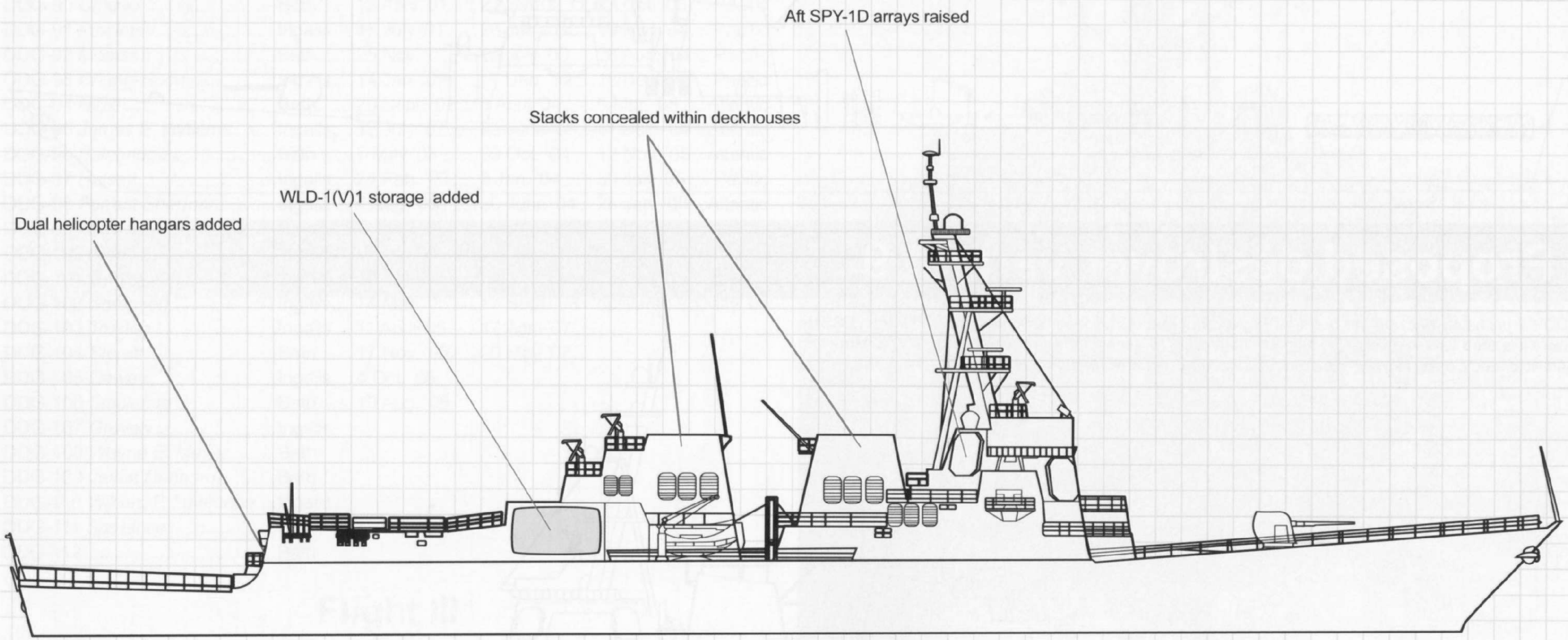
Proposed destroyer variant 9

DDV 9 ultimately became the basis for Flight IIA. It had a VLS load of 96 missiles and Aegis. ESSMs were intended for self-defense instead of Phalanx CIWS. (*based on line drawing from "U.S. Destroyers: An Illustrated Design History," Revised Edition, 2004, by Dr. Norman Friedman*)



Flight IIA (*Momsen* DDG-92)

Momsen shows the changes in the Flight IIA design. The hull was lengthened by 5 feet, but weight-reduction measures kept the tonnage from increasing. The exhaust stacks were enclosed within the deckhouses on DDG-89 and later ships. Two helicopter hangars were included in the design, meaning that one ASW helicopter and one conventionally armed helicopter could be deployed. Below the aft SPG-62 illuminators is a large starboard door for the WLD-1(V)1 remote minehunting system. The Mk 15 CIWS is scheduled to be deleted and replaced with an ESSM system launched from VLS cells. Four ESSMs can be launched from one cell. For additional integrity, five blast-hardened bulkheads were installed amidships in the machinery compartments. The capability of the 5-inch gun was boosted to fire the ERGM, and the RQ-8 Fire Scout VTUAV was added to the ship.



(*based on original line drawing by A.D. Baker III*)

The future — DDG-1000, *Zumwalt* class

With the launch of DDG-112, construction of destroyers will shift to the DD(X) or DDG-1000/*Zumwalt* class now in the advanced design phase. A new concept, the basis of which will be used for a new series of surface warships, DDG-1000 incorporates the latest in automation, low-observable technologies, and crew habitability and is intended to operate in littoral regions. Primary missions concentrate on land attack.

Five are currently scheduled to be built by Northrop Grumman Ship Systems and Bath Iron Works. DDG-1000 and DDG-1001 are funded by Congress in FY 2007 and 2008. Dimensions include a length of 607 feet, a beam of 80.7 feet, and draft of 27.6 feet. Speeds will be up to 31.2 knots. The range at 20 knots is 4,500 nautical miles. Propulsion comes from two Rolls-Royce MT-30 gas turbines with 47,318 SHP each, a total of 97,900 SHP driving two propellers. The gas turbines also drive two alternator sets, 36.5 MW Alstom advanced electric induction motors, components of the Integrated Power System in the first two ships. An exhaust suppressor will be integrated into the stack to reduce infrared emissions. The bow stem is angled forward (wave-piercing tumblehome design), which contributes to the ship's stealth.

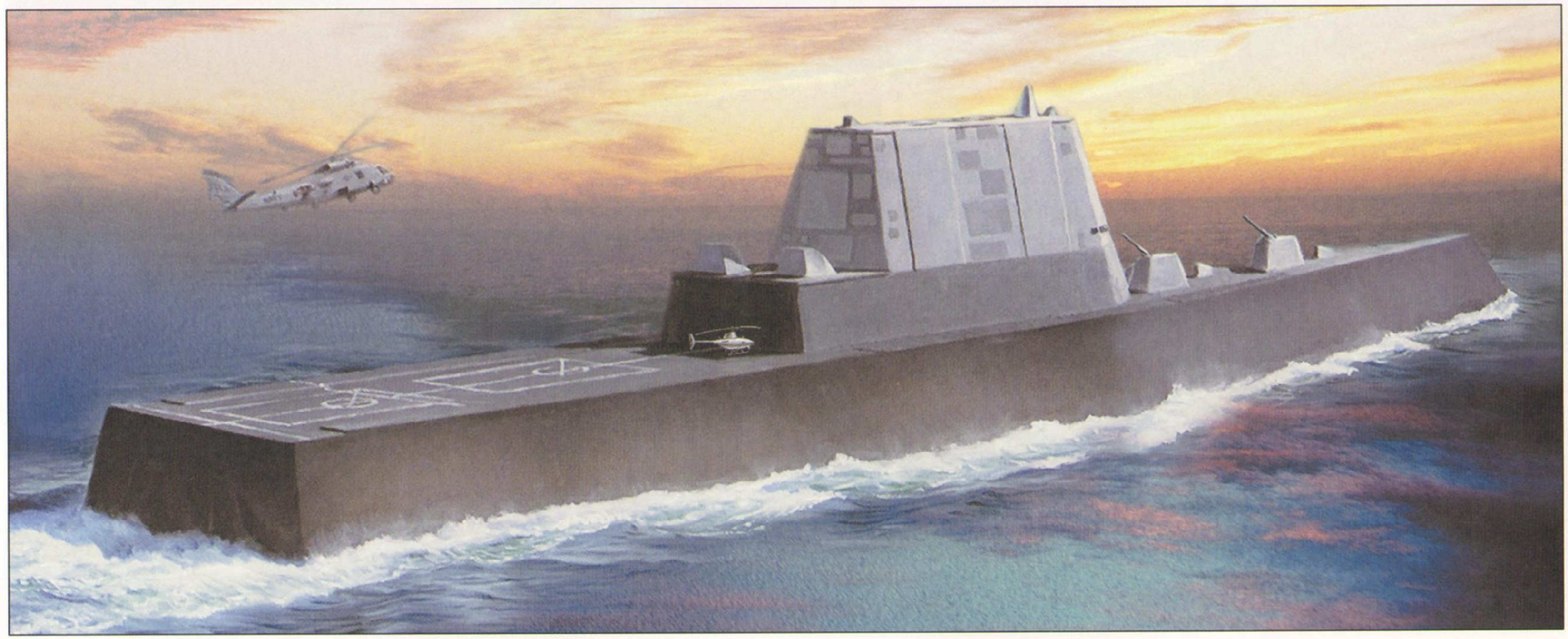
Displacement is 14,264 tons light and 16,033 tons loaded.

DDG-1000 will carry 80 missiles in combinations of Tomahawk, VLA, SM-3 block III/IIIA, and ESSM SAMs in a Peripheral Vertical Launch System arrangement of 20 groups of four cells each, which are not capable of being reloaded at sea. Two 57 mm guns are mounted aft, primarily for anti-aircraft defense. Two Advanced Gun System (AGS) 155 mm weapons forward will launch guided projectiles at land targets with a range of approximately 85 nautical miles. A total of 960 rounds of 57 mm ammunition and 600 rounds of 155 mm projectiles can be carried.

Radars compose a dual-band phased-array system (the SPY-3 X-band for target acquisition, tracking, and illumination and S-band for area search share the same array) and a navigation set. No electronic support measures gear is planned for the first ship. Conformal sensors embedded in the superstructure will eliminate mechanical, high-maintenance antennas and dishes protected in radomes. A dual-frequency sonar is included as well as a multifunction towed array. Countermeasures include SLQ-25A(V) Nixie, Mk 50 decoy system, with six Mk 137 rocket launchers, and 12 launchers for Mk 53 Nulka hovering decoys. Helicopters (two MH-60R or one MH-60R and three RQ-8 Fire Scout VTUAVs) will be embarked in an enclosed hangar amidships. Two RHIBs will also be launched and recovered from the stern. Propulsion spaces normally will be unattended, a result of high automation and computer monitoring. The crew is envisioned to be 14 officers and 100 enlisted personnel plus the air group.

Research, development, testing, and evaluation costs are $3.8 billion. The cost for the first unit is expected to be around $3.29 billion, with future ships estimated at $3.06 billion. Delivery of the first vessel is slated for January 2012, with deployment in 2014.

Able to operate alone or as part of a net-centric team, employing the latest sensors, stealth, and weapons, DDG-1000 will truly bring about a revolution in warship technology. As with all recent purchases of major weapon systems, world climate, the whims of those in political power, and the ever-present cost and size factors will be as much an influence as the operational roles in which this ship is supposed to fight and survive.



An artist's concept shows DDG-1000 under way with an SH-60 helicopter overhead and an RQ-8 Fire Scout VTUAV on deck. The fairings above RQ-8 are for 57 mm anti-aircraft guns. The main battery of 155 mm AGS weapons are shown trained to port. Conformal antennas are plentiful along the sloped sides of the deckhouse. (*Northrop Grumman*)

Modifications

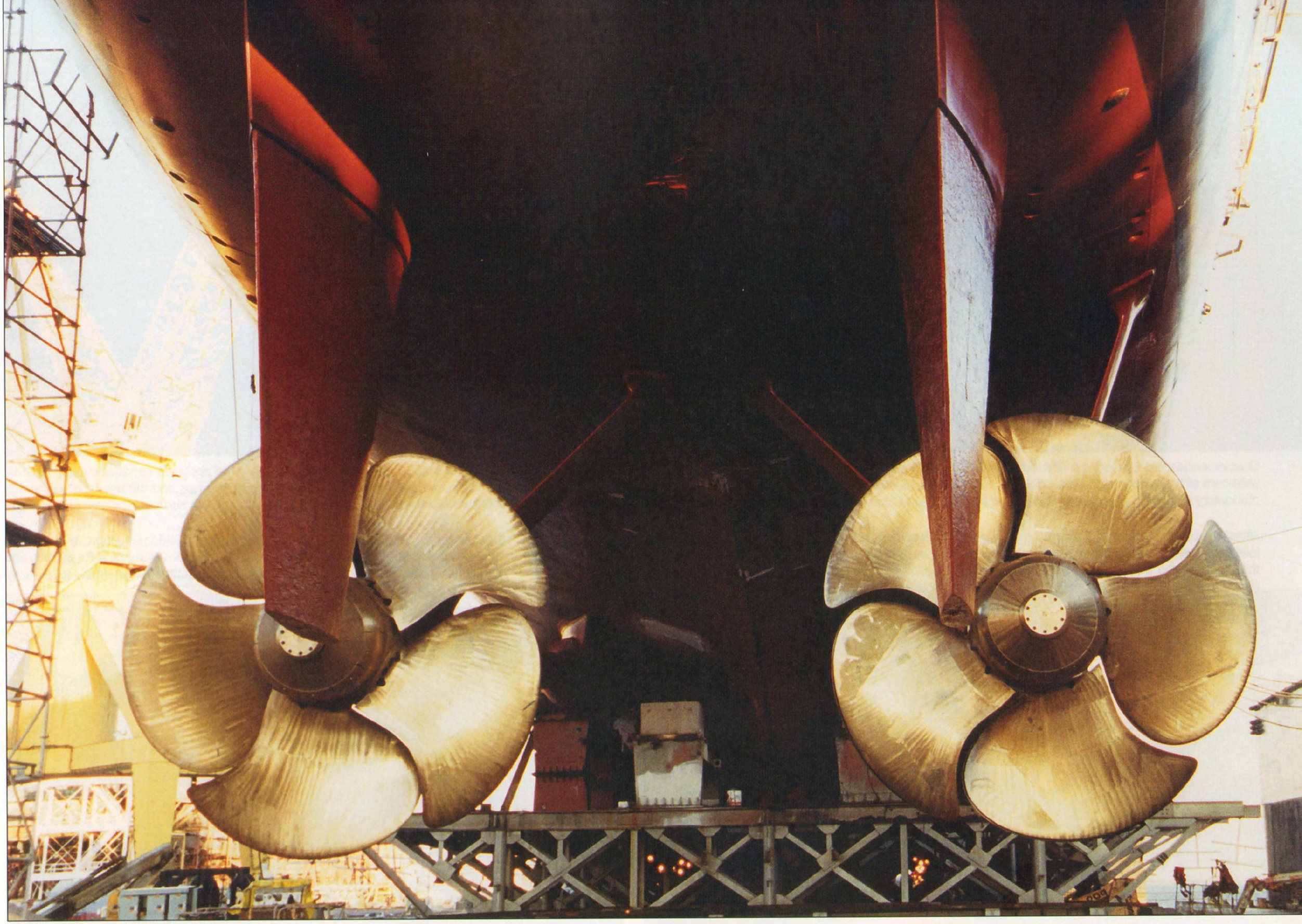
After a new ship class is built, alterations are common as part of planned upgrades and changes. In 1992, the space above the bridge on *Barry* was open (*inset*). *Arleigh Burke* had a similar configuration. *McFaul (*DDG-74) (*main photo)* has a deckhouse added above the bridge, and the Mk 46 Mod 0 electro-optical sensor and fire control device is visible just behind the railing in March 1998. White SATCOM radomes are now gray. The large dish abaft the Mk 46 is one of the SPG-62 illuminators. (*both photos Northrop Grumman*)

Electronics Tech. 1st Class Mark Caprio climbs the upper mainmast of *Carney* while another technician works inside the radome containing the data link antenna for the SH-60B LAMPS helicopter. (*U.S. Navy Photographer's Mate 2nd Class Felix Garza*)

Antennas above the bridge windows of *Winston S. Churchill* (DDG-81) from left include WSC-3 UHF SATCOM, SPG-62 target-illuminating radar, and USC-38 EHF SATCOM. Devices under the bridge wings are SLQ-32 electronic warfare jammers. (*U.S. Navy Photographer's Mate 2nd Class Shane T. McCoy*)

Water and air are forced through the starboard propeller on *Churchill* at Bath Iron Works in August 2002 to test the system that reduces the screw's vibrations. A controllable-pitch design allows the blade angle to be adjusted for optimum performance. (*U.S. Navy Intelligence Specialist 1st Class Holly Hogan*)

The large forefoot on *Lassen* contains the transducer for the SQS-53 sonar. Up to 100 targets can be tracked, even while the ship is in motion or in shallow water. The location of the stem anchor ensures that it will not strike the sonar dome. (*U.S. Navy Mass Communication Specialist Seaman Kari R. Bergman*)



Chung-Hoon (DDG-93) shows off her two shaft-driven propellers and rudders as she rests aboard a floating dry dock at Ingalls Shipyard, in Pascagoula, Mississippi. Much design work went into making these ships agile and maneuverable while taking into account the limitations of stress on such a large hull. (*Ingalls Shipbuilding*)

Gunner's Mate 3rd Class John Wiederhold checks a VLS panel's status and communicates with other members of his department on board *John S. McCain* (DDG-56). The fire resistant hood and gloves are mandatory protection. (*U.S. Navy Photographer's Mate 2nd Class Felix Garza*)

A crash and rescue fire drill simulating an incident involving a helicopter is conducted on *Fitzgerald* (DDG-62) while at sea. All sailors are proficient in fire suppression tactics and the use of equipment in case of such an accident. (*U.S. Navy Photographer's Mate Airman Adam York*)

After being fired, the 5-inch gun barrel on *Shoup* (DDG-86) is cleaned by Gunner's Mate 2nd Class Michael West. A wooden pole is used to prevent damage to the inner surface while sliding cleaning materials down the length of the barrel to remove residue and apply a protective coating for the next round of firing. (*U.S. Navy Photographer's Mate Airman James R. Evans*)

Torpedoman's Mate 3rd Class Kelly Trahan explains the operation of a Mk 32 torpedo launcher to cadets in the Philippine Navy while touring *Paul Hamilton* (DDG-60) during a Cooperation Afloat Readiness and Training exercise. This kind of personal interaction during port calls is mutually beneficial. (*U.S. Navy Photographer's Mate 1st Class David Votroubek*)

An effective damage-control network is vital to survival in combat at sea. A fireman on board *Gonzalez* (DDG-66) monitors a fire main panel used to open and close valves directing water to various compartments in the ship to fight internal fires. (*U.S. Navy Photographer's Mate 3rd Class Todd Linard*)

While in the Persian Gulf in December 2005, a gas turbine technician monitors the propulsion auxiliary control panel on board *Donald Cook*. Four General Electric LM-2500 gas turbines give the ship the ability to reach speeds faster than 30 knots. (*U.S. Navy Chief Operations Specialist Morris Lowery Jr.*)

From the landing signal officer (LSO) station, Lt. j.g. Ike R. Stutts recovers an SH-60B on board *Oscar Austin* (DDG-79) at sea in November 2002. The LSO station is at the forward starboard edge of the helicopter pad. (*U.S. Navy Photographer's Mate 1st Class Michael W. Pendergrass*)

A general quarters drill on *Higgins* (DDG-76) requires the crew to don helmets and fire-resistant hoods and gloves. These sailors are at the helm station on the bridge. (*U.S. Navy Photographer's Mate 1st Class Kevin H. Tierney*)

Crew members of *Hopper* (DDG-70) paint the side of the ship while it's moored at Naval Station Pearl Harbor, Hawaii. (*U.S. Navy Mass Communication Specialist Seaman Daniel A. Barker*)

Painting is a full-time chore as the hull number on *McCampbell* is given attention. (*U.S. Navy Chief Journalist Melinda Larson*)

From left, U.S. Navy Cryptologic Technician 1st Class Robert Bonte, Gunner's Mate 3rd Class Timothy Green, and Quartermaster 3rd Class Mike Thoumire heave on an anchor chain on *Curtis Wilbur* (DDG-54). (*U.S. Navy Mass Communication Specialist 2nd Class Nardelito Gervacio*)

The stem anchor on *Oscar Austin* is sprayed off as the ship leaves the pier at Norfolk, Virginia. The location of the anchor prevents it from striking the sonar dome. (*U.S. Navy Photographer's Mate 2nd Class Michael Sandberg*)

The 5-inch gun on *Forrest Sherman* (DDG-98) is touched up before commissioning. The rectangular device at the base of the gun barrel is a UPQ-6 velocimeter used to measure projectile velocity. (*U.S. Navy*)

Mooring lines are taken off the bits as *Shoup* prepares to get under way. (*U.S. Navy Photographer's Mate 2nd Class Eli J. Medellin*)

This 25 mm Mk 38 chain gun on *Benfold* (DDG-65) has an ammunition capacity of 150 linked cartridges. Its rate of fire is either single shot, 100 rounds per minute, or 200 rounds per minute. (*U.S. Navy Photographer's Mate 2nd Class Rebecca Kearns*)

The forward Mk 15 CIWS on *Benfold* is tested in the Pacific Ocean. The CIWS destroys air threats by using two radars in the upper section to merge the radar tracks of the target and the rounds being fired. (*U.S. Navy Photographer's Mate Airman Jordon R. Beesley*)

A 40 mm grenade is propelled from a Mk 19 grenade launcher during firing practice on *Hopper* in September 2006 during familiarization exercises. These weapons, with a firing rate of 400-450 rounds per minute, are widely used by the U.S. Army and Marines on armored vehicles. The muzzle velocity is 800 feet per second, and the range is 2,400 yards. (*U.S. Navy Mass Communication Specialist John L. Beeman*)

A *Curtis Wilbur* gunnery crew fires the 25 mm chain gun during a practice session. The weapon is known in the U.S. Army as the M242 Bushmaster. It is manually aimed, and the barrel has a life of 25,000 rounds. Its elevation is +55 degrees, and its depression is -20 degrees. The muzzle velocity is 3,608 feet per second, and it has an effective range of 8,100 yards. It is used on major surface combatants as well as on special operations craft. (*U.S. Navy Photographer's Mate 3rd Class Yesenia Rosas*)

Russell (DDG-59) fires a 5-inch round during an August 2005 Pre-Aim Calibration Fire exercise in the Pacific. The gun can fire 70-pound shells up to 25,900 yards at a muzzle velocity of 2,650 feet per second. The gun crew consists of six people operating the weapon from below decks. The gun can be elevated +65 degrees and lowered -15 degrees. The working circle is an arc of 261 degrees. The barrel has a lifetime of 7,000 rounds. (*U.S. Navy Photographer's Mate 1st Class Richard J. Brunson*)

Off the Virginia Capes, a Mk 45 Mod 4 5-inch gun is fired aboard *Winston S. Churchill*. Angular panels on the turret are designed to reflect radar waves. The turret is unmanned, and between 16 and 20 rounds per minute can be fired. (*U.S. Navy Lt. j.g. Caleb Swigert*)

Gunner's Mate 3rd Class Arthur Bilbey stacks 5-inch rounds onto an ammunition elevator while *Curtis Wilbur* is in port at Yokosuka, Japan. The yellow bands indicate that each round has high explosive content. (*U.S. Navy Photographer's Mate 2nd Class John Beeman*)

A TLAM is fired from the forward VLS module of *John Paul Jones* (DDG-53) during attacks against Al-Qaida training camps in Afghanistan in October 2001. Windows in the missile enable the Terrain Contour Matching navigation system to detect ground features. (*U.S. Navy Photographer's Mate 1st Class Ted Banks*)

Winston S. Churchill launches a TLAM from the aft VLS while in the eastern Mediterranean Sea during Operation Iraqi Freedom. The TLAM's range is 675 nautical miles with a 1,000-pound warhead. The missile weighs 3,181 pounds. (*U.S. Navy Chief Fire Controlman James Krogman*)

A Mk 14 canister containing a BGM-109 Tomahawk cruise missile is offloaded from *Curtis Wilbur* during a port visit to Yokosuka, Japan. Missiles are loaded and shipped in their own custom canisters and require missile-specific adapters. (*U.S. Navy Photographer's Mate 2nd Class John L. Beeman*)

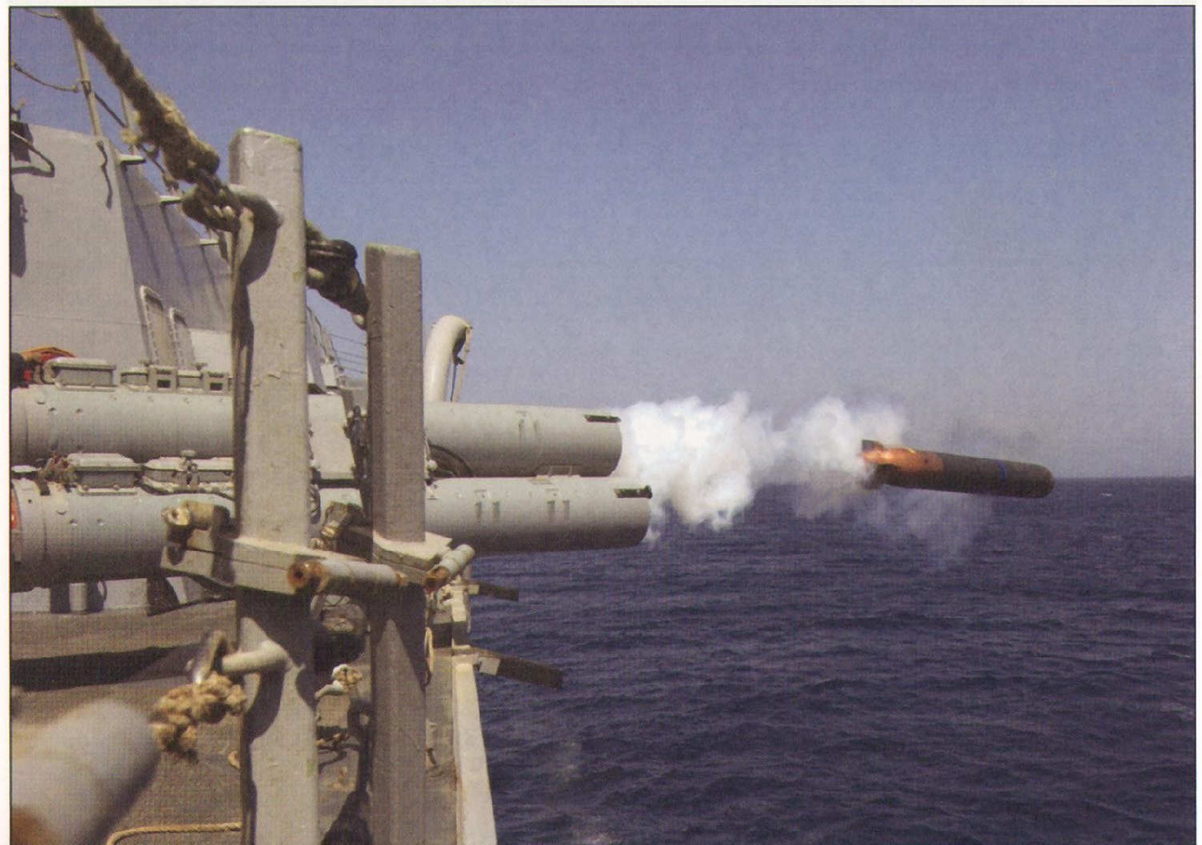
A TLAM begins its flight From *Milius* (DDG-69) to a target during Operation Iraqi Freedom. The aft Mk 41 VLS magazine on *Milius* can hold 61 rounds. VLS modules can be loaded with combinations of TLAMs, SM-2s, Sea Sparrows, or VLAs. (*U.S. Navy Photographer's Mate 1st Class Thomas Lynaugh*)

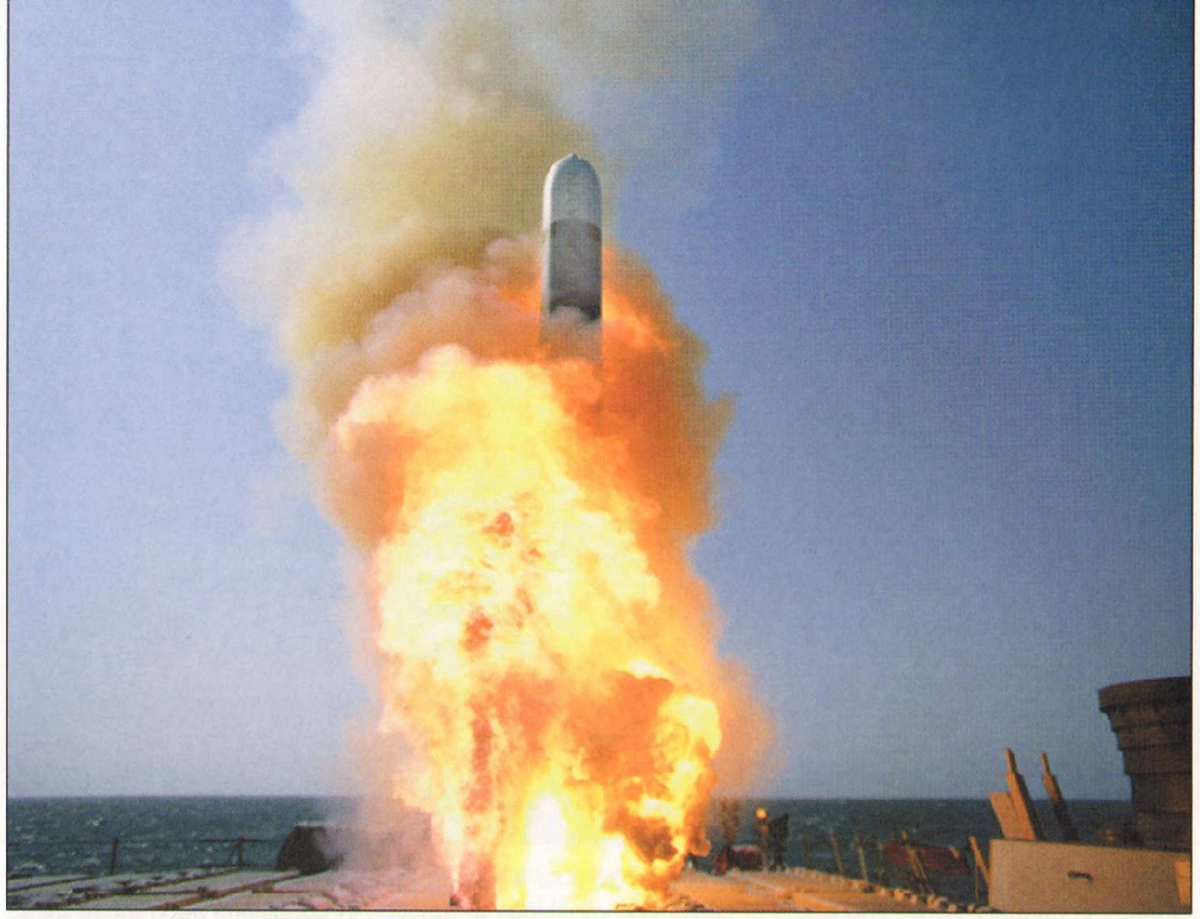
With the exhaust trail of a previous TLAM launch visible, *Milius* fires another during Operation Iraqi Freedom. (*U.S. Navy*)

During a Combat Systems Ship Qualification Test, *Preble* (DDG-88) fires a Mk 46 Mod 5 Near-Term Improvement Program torpedo from a Mk 32 Mod 15 triple launcher. The weapon is ejected by compressed air. (*U.S. Navy Photographer's Mate Ramon Preciado*)

Porter fires a TLAM with an assist from a small solid booster. Once the booster burns out, the wings, tail surfaces, and air intake deploy, the engine starts, and the missile begins its programmed flight to an assigned target. (*U.S. Navy*)

A Mk 50 Advanced Light Weight Torpedo training round is launched from *Bulkeley* (DDG-84) in the Persian Gulf while supporting Operation Iraqi Freedom. A Mk 50 Barracuda weighs 771 pounds and has an operating depth of 3,600 feet. (*U.S. Navy Photographer's Mate 1st Class Brien Aho*)





Stethem (DDG-63) launches a TLAM. The missile traveled 760 miles to hit its target. The newest versions can be reprogrammed to new targets in flight and can loiter over an area and send images to controllers in real time. (*U.S. Navy*)

Sailors inspect open aft VLS hatches on *Fitzgerald* in September 2005, checking for water accumulation, which could cause electrical problems. Hatches are solid steel to protect the missiles. Inside the round containers in the background are anti-ship Harpoon missiles. Up to eight of these can be deployed on Flight I and II ships. (*U.S. Navy Photographer's Mate Adam York*)

An SM-2 SAM rides a pillar of flame as it exits an aft VLS cell on board *O'Kane* (DDG-77). Up to 61 missiles could be stored in the aft VLS, with another 29 forward. The SM-3 version has demonstrated a ballistic missile defense capability. (*U.S. Navy Mass Communication Specialist 3rd Class Manos T. Hernandez*)

An SH-60B lifts off from *Mason*. The ship turns into the wind to facilitate takeoffs and landings. On deck below the helicopter is the RAST device used to winch the helicopter down to the deck in rough seas. (*U.S. Navy Journalist Seaman Joseph Ebalo*)

An MH-60S gets ready in rough seas to depart *Benfold* while en route to aiding victims of the Asian tsunami in January 2005. The ability of crews and machines to function in conditions such these takes skill, balance, and faith in equipment. (*U.S. Navy Photographer's Mate Airman Ronald Dallatorre*)

SH-60F Seahawk 164799/AG-610 from HS-5 the "Night Dippers" assigned to *George Washington* takes on bags of mail from *Ross* (DDG-71). Helicopters easily move cargo, ammunition, personnel, and spare parts among surface ships. (*U.S. Navy*)

In a vertical replenishment delivery, an MH-60S Knighthawk of HC-6 "Chargers" brings cargo to the deck of *Bulkeley* in the Persian Gulf. The gun turret is turned to starboard so its barrel does not interfere with the aerial maneuver. (*U.S. Navy Photographer's Mate 1st Class Brien Aho*)

An HH-60H fires an AGM-114B Hellfire laser-guided missile. Hellfire was originally developed for use on the U.S. Army AH-64A Apache gunship helicopter. The missile weighs 108.5 pounds. It has a speed of Mach 1.3 and a range of 4.3 nautical miles. The warhead is a shaped charge that weighs 14.8 pounds. (*U.S. Navy*)

A cargo ship is scanned with the AAS-44 forward-looking infrared turret of an SH-60B during Operation Iraqi Freedom. AAS-44 has three levels of magnification and a laser to designate targets for attack with AGM-114 Hellfire missiles. (*U.S. Navy*)

A U.S. Navy Sea, Air, Land (SEAL) team fast-ropes from an SH-60F onto the deck of *Oscar Austin* as another helicopter observes and provides cover during a boarding exercise. (*U.S. Navy*)

Decatur prepares to refuel at sea while under way in the Pacific Ocean in January 2006 in support of the Global War on Terror. Maintaining speed and distance between the two vessels is critical as fuel and supplies are offloaded. (*U.S. Navy Photographer's Mate Airman Kathleen Gorby*)

Using an M14 rifle with a Mk 87 line-throwing adapter, a messenger line is fired onto the deck of *Walter S. Diehl* (T-AO 193) from *Carney*. Larger lines are moved across the two vessels until heavy supply lines and refueling hoses are connected. This operation delivered 100,000 gallons of fuel and 26 pallets of food and supplies. (*U.S. Navy Chief Journalist John F. Williams*)

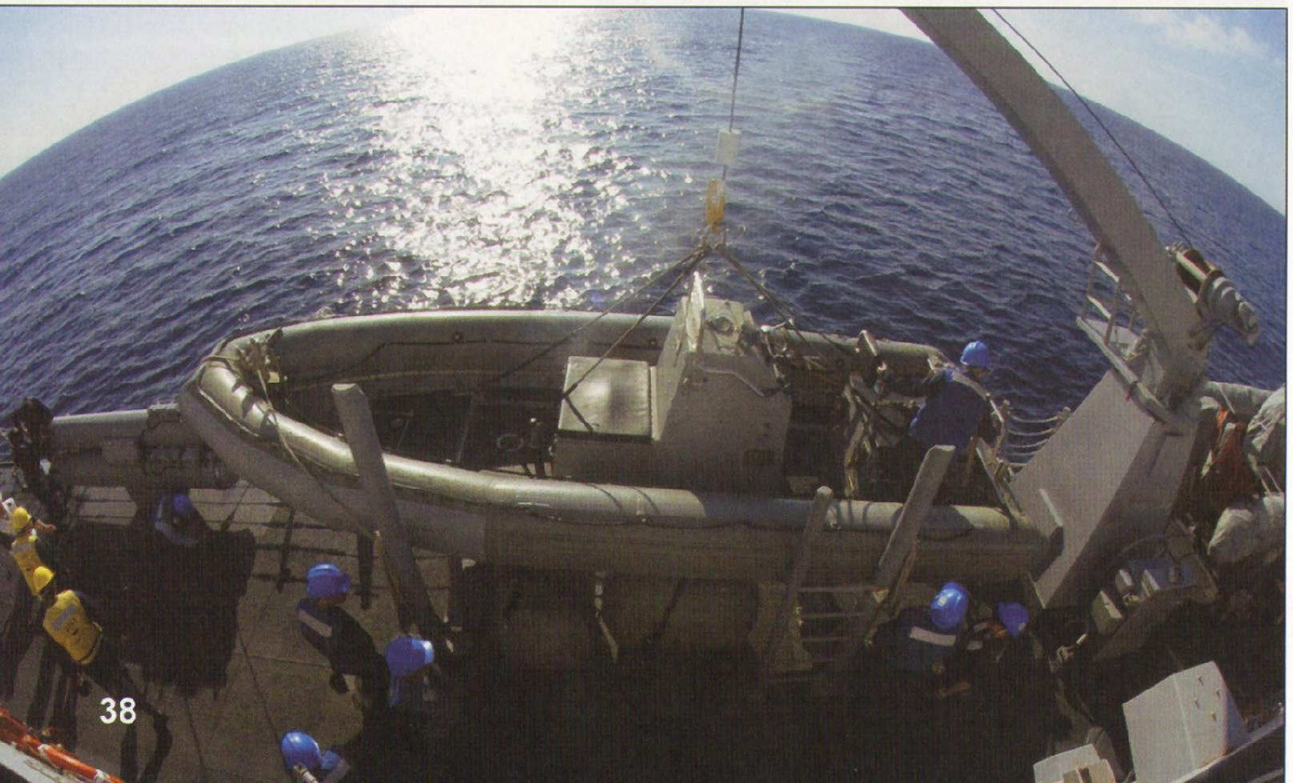
During Operation Iraqi Freedom, *Donald Cook*'s crew secures heavy cables for the transfer of supplies from a replenishment oiler of the *Henry J. Kaiser* class. These ships can carry 390 tons of potable water and 534 pallets of dry cargo. (*U.S. Navy Chief Journalist Alan J. Baribeau*)

McCampbell steams alongside *Ronald Reagan* (CVN-76). The ability of aircraft carriers to replenish escorting vessels provides flexibility and extends endurance of the strike group when dedicated logistical support is not available. (*U.S. Navy Photographer's Mate 1st Class James Thiery*)

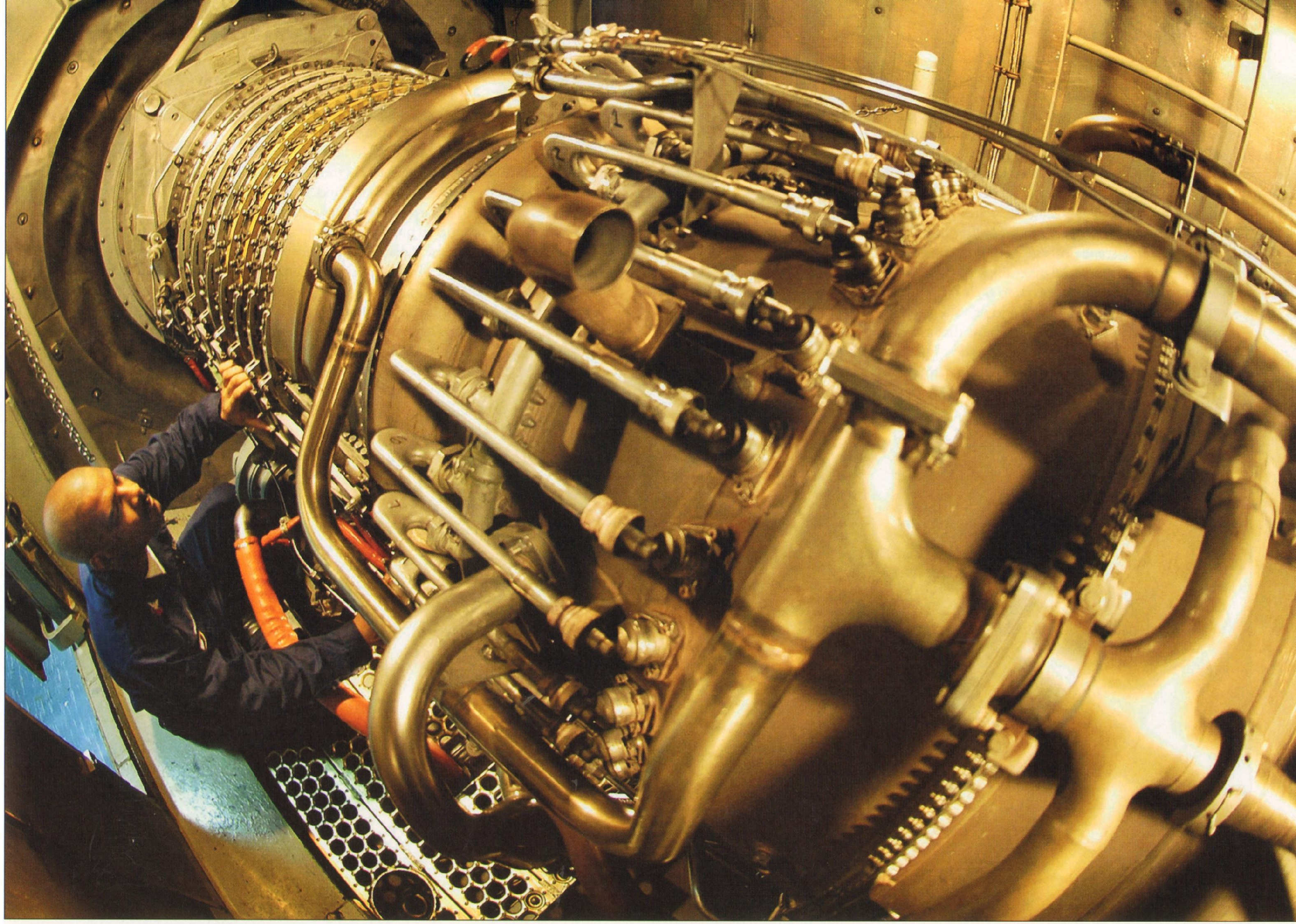
In the left photo, *John S. McCain* prepares to rig a towline to the *Ticonderoga*-class cruiser *Vincennes* (CG-49) off the Japanese coast. At right, the towing exercise begins, and the objective of towing a disabled vessel for 15 minutes at 5 knots was achieved. Drills such as this Tailored Ship Training Availability activity challenge crews of both ships in rigging the cable, maintaining specified goals, and working together. (*both photos U.S. Navy Photographer's Mate 2nd Class Brandon A. Teeples*)

A boarding team departs *Winston S. Churchill* en route to a suspected pirate vessel as part of a VBSS operation in January 2006. (*U.S. Navy Chief Information Systems Technician Kenneth Anderson*)

Two RHIBs are carried on *Arleigh Burke*-class ships. On board *Mason*, the crew recovers an RHIB using a slewing arm davit during a composite training unit exercise. (*U.S. Navy Photographer's Mate 3rd Class Pedro A. Rios Alvarez*)



While *Preble* observes, a combined American and Pakistani crew man an RHIB in the Persian Gulf during exercise Inspired Siren in September 2004. Such joint interactive maneuvers build trust and allow both sides to learn tactics and work together. (*U.S. Navy Photographer's Mate 2nd Class Aaron Peterson*)



A crew member inspects one of *Russell*'s General Electric LM-2500 gas turbine engines, the key to the *Arleigh Burke* class' high speeds and maneuverability. Four of these power plants generate up to 105,000 SHP and push the ships to 31 knots or faster. (*U.S. Navy Photographer's Mate 3rd Class Jordon R. Beesley*)

Shipboard electronics

The electronic systems on *Arleigh Burke*-class ships serve a multitude of purposes. Data link connections feed surface or subsurface contact information from a helicopter to the ship in real time for analysis or a tactical response in the form of a torpedo attack or the firing of an anti-ship missile. SATCOM stabilized antennas receive and transmit messages clearly and completely as the ship rolls or pitches in a heavy sea or maneuvers. Surface search radars such as SPS-67(V)4 detect submarine periscopes in moderate sea states. SPS-64(V)9 or Bridge Master E sets (DDG-87 and later) enable precise navigation in shallow littoral waters. Aegis long-range radars provide a picture of the battle scene on large screens in the combat information center, showing aircraft, land masses, cruise missiles, and other ships. SPG-62 radars illuminate targets for SM-2 and SM-3 missiles moving at supersonic speeds to their targets. Electronic systems are vital to any modern navy undertaking tactical operations and prevailing in sea warfare.

People who own a home computer know that in a matter of months, the system they bought could be modified to work faster with upgrades. The same goes for naval systems. As ships come due for yard overhauls or systems upgrades, many devices are landed, and new units take the place of older, less-capable ones. Many ships in the same class receive different antenna or radome arrangements as shipyard overhauls come due for each ship.

As SATCOM systems mature with the ability to handle increased message traffic in less time, inevitably the antennas grow larger. Most of these dish antennas are enclosed in radomes to protect them from the effects of salt air, water, and wind. USC-38 EHF SATCOM is a perfect example of this; it has been upgraded since it was first deployed on *Arleigh Burke*-class ships. WSC-6 was also included in the last few years to provide super-high-frequency reception.

Often, these systems all emit radiation simultaneously. Early in the development of these devices, designers realized that to give all of them an opportunity to work together, their performance must be intentionally degraded so signal transmission and reception occurs over many frequencies.

As the new DDG-1000 becomes a reality, the cluttered, complex, and maintenance-intensive arrangements of today will be replaced with conformal antennas that will be fitted into the surfaces of the superstructure. This is made possible by the ability to shift beams of energy, the increased sensitivity of sensors, and the dispersal of flat antennas arranged to give optimal coverage from many directions.

Antennas in detail

Voice

Antenna	Type	Function
HF	AS-3773	HF communications
UHF	AS-1735	UHF communications
UHF/VHF	AS-2867	UHF/VHF communications

Radar

Antenna	Type	Function
SPS-64	AS-3194	Navigation
SPS-67	AS-936	Surface search
Bridge Master E	N/A	Surface search (DDG-87 and later)
SPG-62	AS-3156	Target illumination
SPY-1D	AS-3159	Long-range air search, tracking

Data link

Antenna	Type	Function
LAMPS	AS-3274	SH-60 helicopter data
LAMPS	AS-3275	LAMPS omni antenna
USG-2 CEC	AS-4460	Cooperative engagement capability
JTIDS	AS-4127/4127A	Joint Tactical Information Distribution System

Electronic warfare

Antenna	Type	Function
SLQ-32	N/A	Active jammer
SRS-1	AS-3506/AS-3202	Combat direction finder (Flight II and IIA only)

Doppler tracking

Antenna	Type	Function
UPQ-6 velocimeter	N/A	5-inch gun projectile velocity

IFF

Antenna	Type	Function
UPX-29	AS-3134	Identification friend or foe

TACAN

Antenna	Type	Function
URN-25	AS-3240	Tactical air navigation

Satellite communication

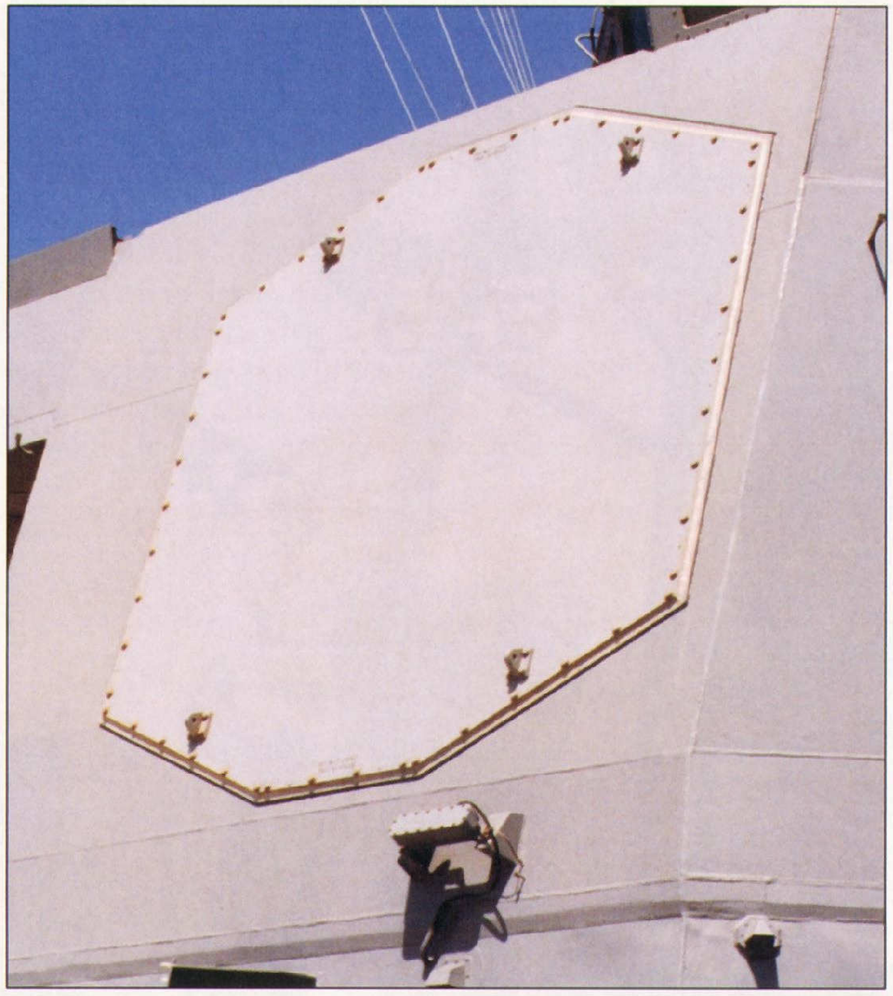
Antenna	Type	Function
WSC-3	AS-3018	UHF SATCOM
USC-38	AS-4294	EHF SATCOM
WSC-6	AS-4431	SHF SATCOM
SSR-1	AS-2815	Receive-only fleet broadcasts

Satellite communications

Labeled are the SATCOM systems on *Shoup*. Antenna designations are in parentheses. (*author*)

Radars

The SPY-1D Aegis antennas, AS-3159, are used for optimum performance in littoral regions where advanced processing eliminates interference from land masses. The small rectangular antenna below this AS-3159 on *Porter* is an AS-3202, used in conjunction with the SRS-1 Combat DF system. (*author*)

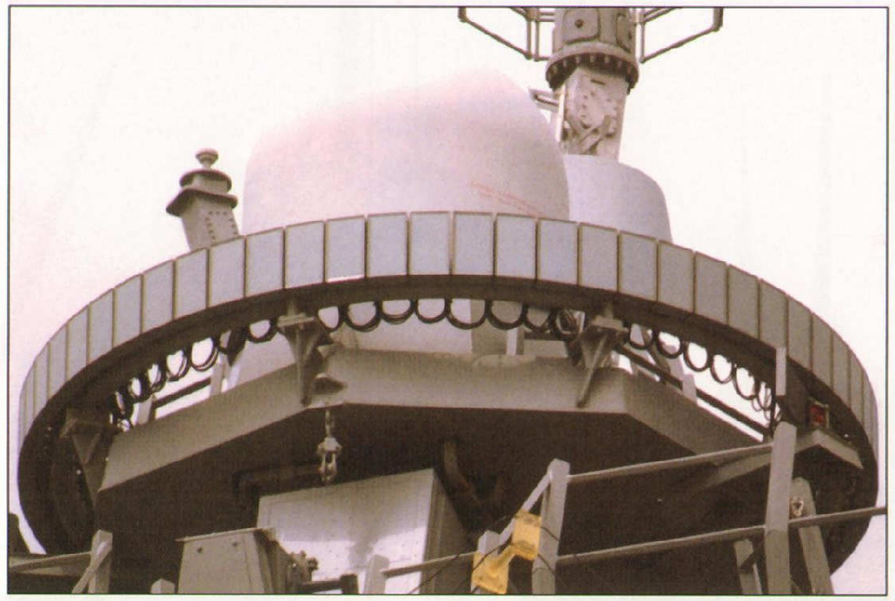


The SPS-67(V)4 surface search radar is mounted on the mainmast of *Porter*. This version has a more robust and reliable design than earlier models and is located on a platform on the mainmast facing forward. (*author*)

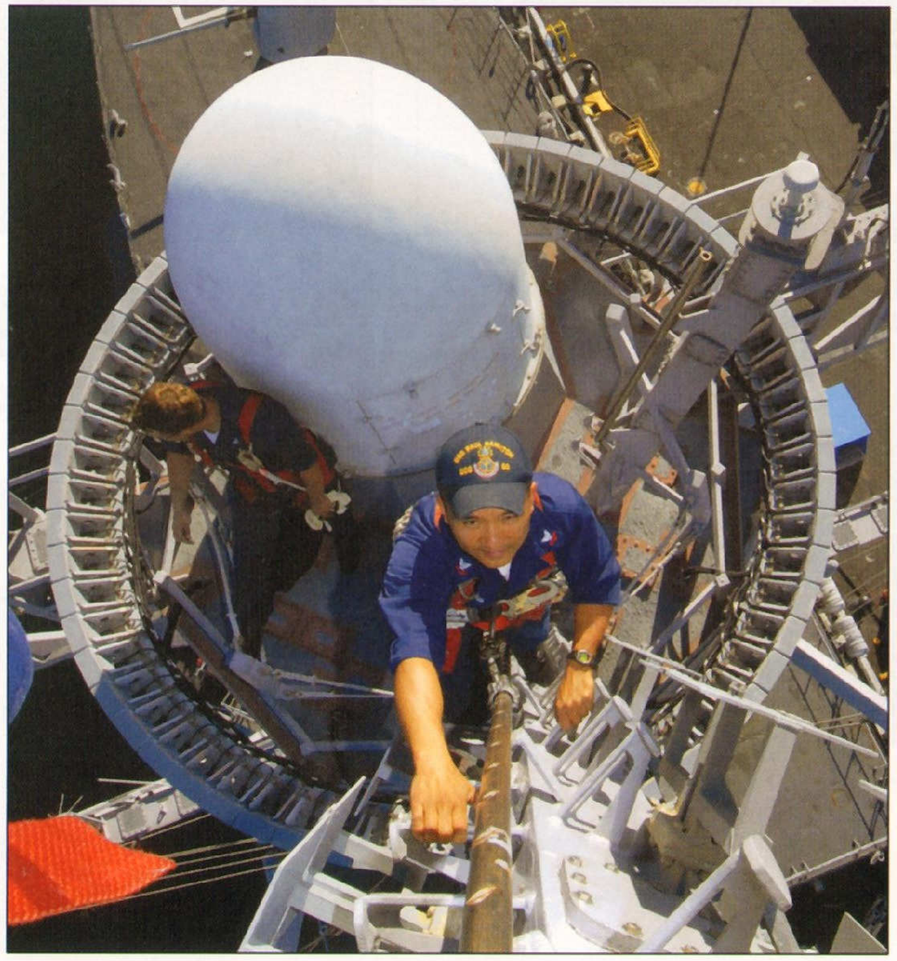
Dual aft-facing SPG-62 Aegis illuminating radars are mounted on *Porter*. The antennas are designated AS-3156 and are used to guide SM-2 missiles to targets. *Arleigh Burke*-class destroyers have three of these radars, two facing aft and one facing forward. (*author*)

Identification friend or foe

A view of the backside of *Barry*'s mast shows several of her antennas, including the 64-element AS-3134 array surrounding the light gray radome for the LAMPS helicopter data link antenna. (*U.S. Navy*)

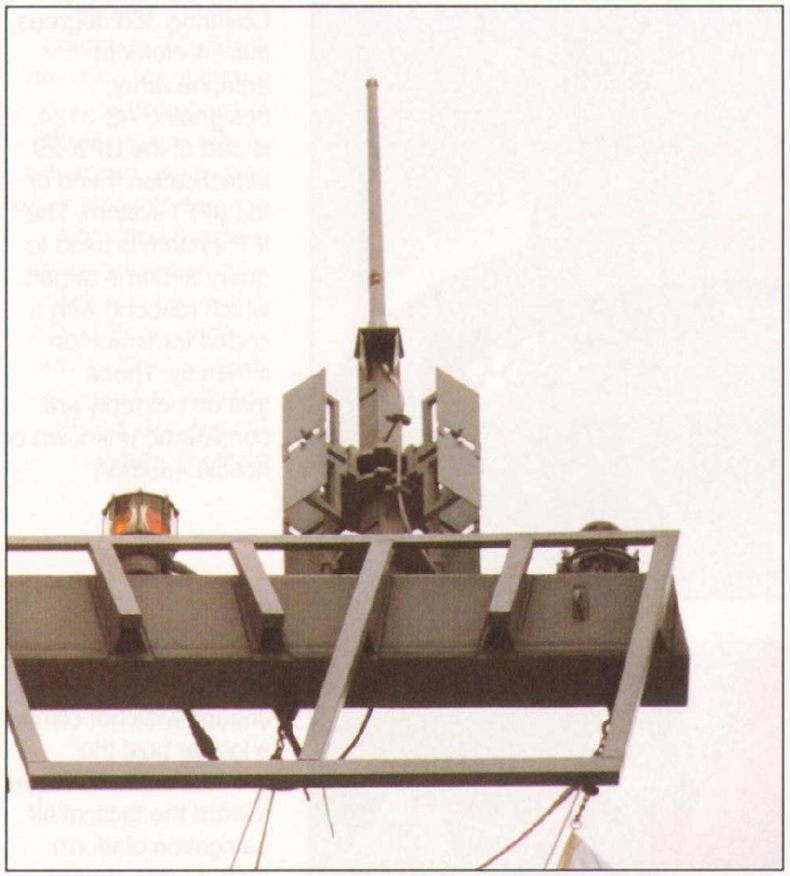


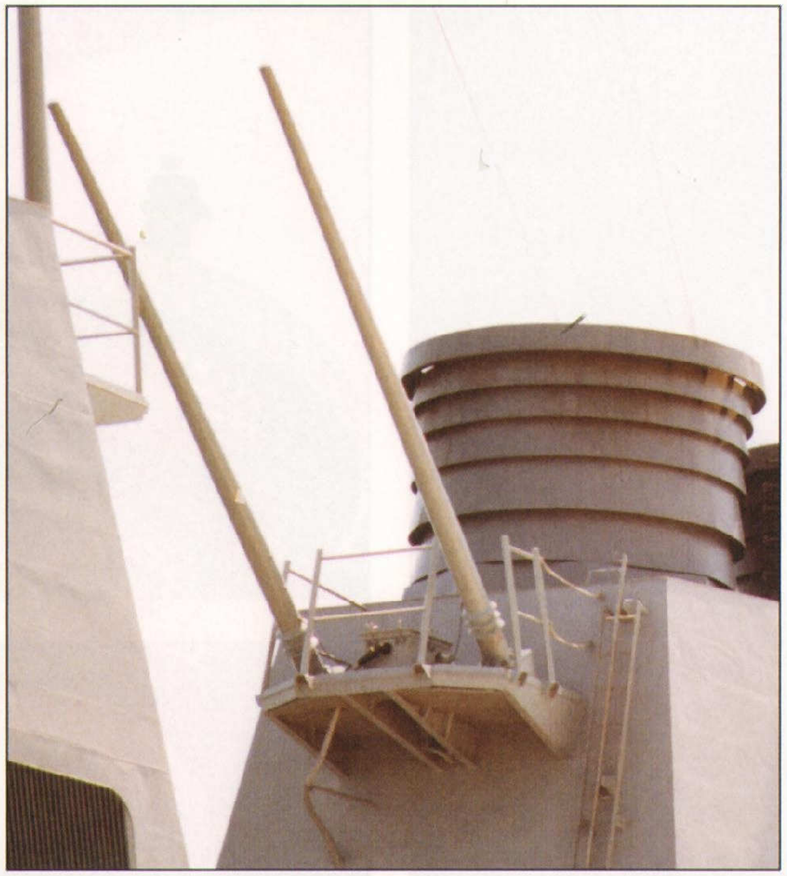
Covering 360 degrees, this 64-element antenna array, designated AS-3134, is part of the UPX-29 identification friend or foe (IFF) system. The IFF system is used to query airborne targets, which respond with a coded transmission if friendly. Those that do not reply are considered unknown or hostile. (*author*)

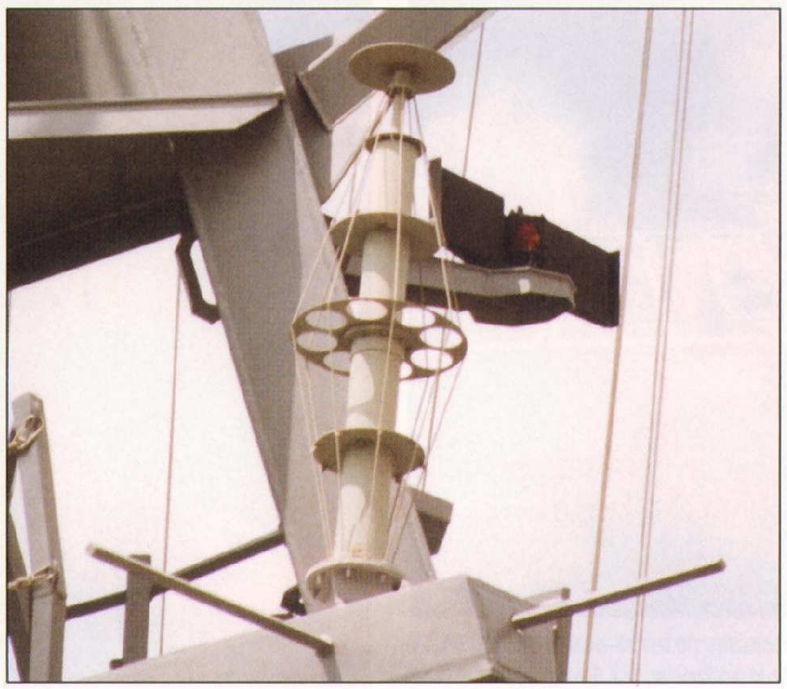


U.S. Navy Electronics Technician 2nd Class Joseph Melchor climbs a ladder past the AS-3134 antenna array toward the tactical air navigation platform on the mast aboard the *Paul Hamilton* while at port in Pearl Harbor, Hawaii, on 24 January 2007. (*U.S. Navy Mass Communication Specialist 1st Class James Foehl*)

Voice communications







Above: The AS-1735 UHF antenna design is wrapped around vertical mounts located at both ends of the mainmast yardarms. They are also seen under the JTIDS antenna atop the mainmast. (*author*)

Top center: Dual AS-3773 antennas for high frequency voice communication are angled aft of the exhaust stacks. (*author*)

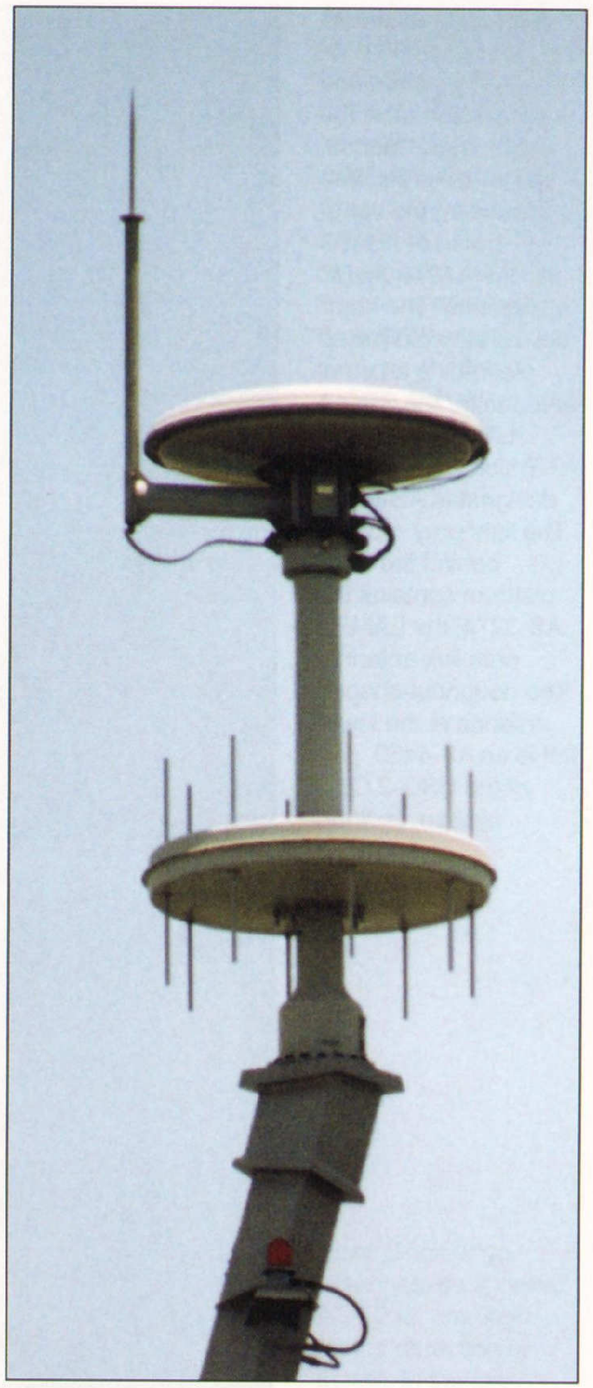
Far right: Two more AS-3773 antennas are located on the fantail. Fantail antennas are adjustable by means of the OA-9242 antenna tilting mechanism. (*author*)

Right: An AS-2867 broadband antenna is used for UHF and VHF communication. The antenna weighs 50 pounds. (*author*)

Tactical air navigation and direction finding

At the top of *Porter*'s mainmast is the AS-3240 antenna, the latest in the long line of TACAN antenna designs. For optimum use, these systems are always mounted at the top of a mast. What makes this device special is its light weight, which is due to the use of electronic scanning rather than the heavier, mechanical rotating components of past devices. TACAN provides navigation data as the ship moves so friendly aircraft can determine where the ship is at all times. A lightning rod projects above this example, part of the URN-25 system. (*author*)

Below the saucer-shaped URN-25 TACAN antenna, *Mason* has the AS-3506 SRS-1 Combat DF array used to detect, analyze, and classify electronic emissions. (*author*)

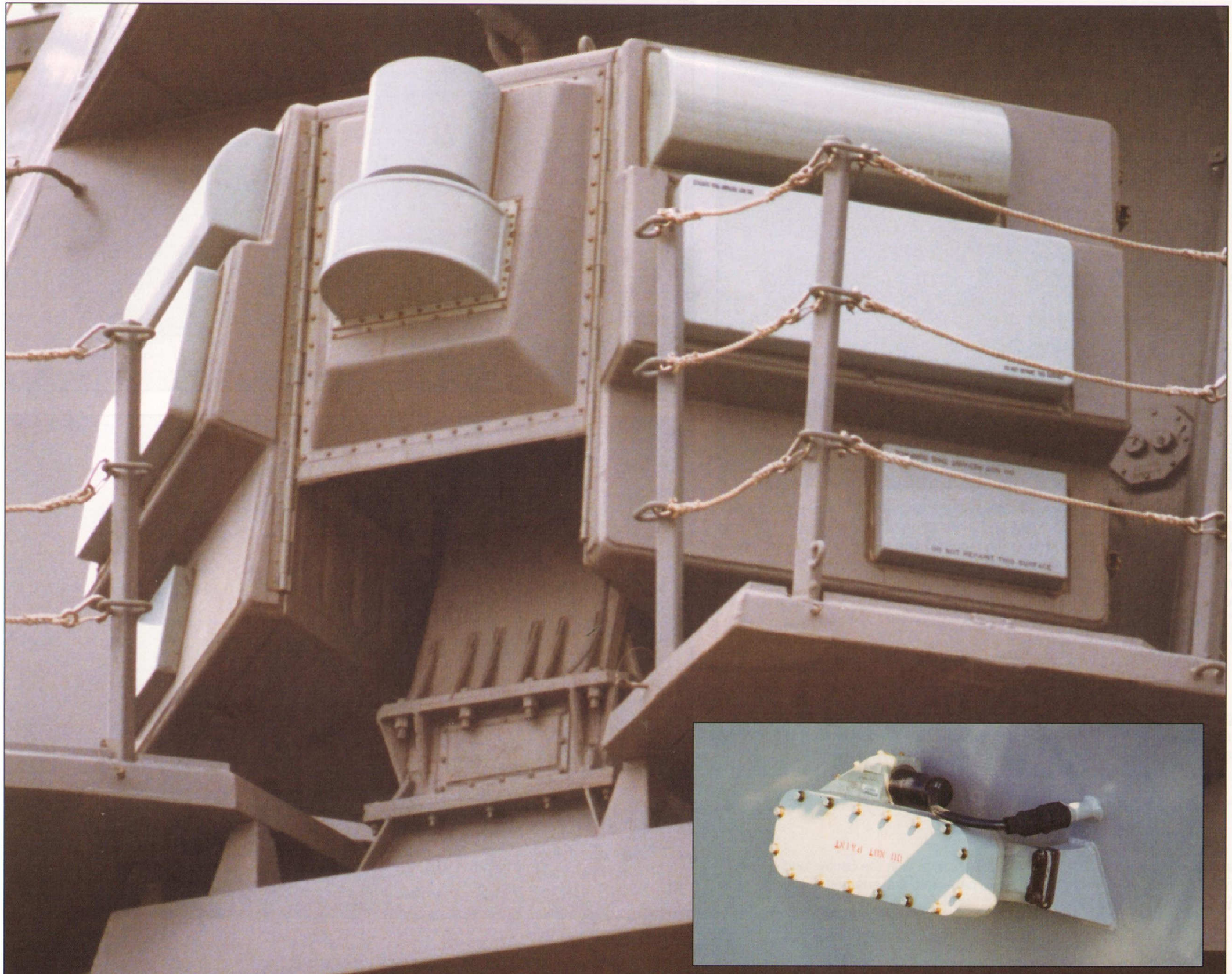


An updated combat DF array is on the mainmast of *Stout*. (*author*)

Data links

A group of antennas dedicated to data link reception and transmission is on the mainmast of *Mason*. The truncated radome surrounding the upper section of mast is an AS-4127A JTIDS antenna. The small device atop the raised platform is an omni antenna for the SRQ-4 LAMPS data link. The omni antenna is designated AS-3275. The light gray radome behind the omni platform contains the AS-3274, the LAMPS data link antenna. The doughnut-shaped antenna at the lower left is an AS-4460, part of the USG-2 CEC system. (*author*)

Electronic warfare



Left: The active jammer, known as SLQ-32(V)3, is used by major combat vessels as an additional sensor to other similar devices on board. The unit is stabilized and can automatically engage countermeasures, such as chaff, and radiate signals intended to defeat radar-guided weapons. (*author*)

Inset: Deck-edge antennas, designated AS-3202, are used for the detection of threats in the low bandwidth. Several of these are located around the ship; this one was photographed on the stern of *Porter*. (*author*)

Radar cross section, infrared countermeasures

Above: The reduction of reflected radar energy is a vital design enhancement for survivability at sea in a conflict. Many anti-ship missiles use radar to seek out and close in on targets. *James E. Williams* (DDG-95) approaches *Wasp* (LHD-1) in the Atlantic Ocean. The faceted gun turret, sloped deckhouses and hull sides limit radar reflectivity. The hidden exhaust stacks lower infrared sensitivity. Radomes and their associated mounts have been modified to minimize the ship's radar return. (*U.S. Navy Photographer's Mate 3rd Class Timothy Bensken*)

Top right: On *Porter*, a Flight II ship, the exhaust stacks have multiple spaced rings that channel cooler air in with the hot exhaust as it vents upward. This reduces the exhaust gas temperature. In addition, the exposed ductwork is not as hot, rendering it less sensitive to heat-seeking weapons. (*author*)

Bottom right: On *Stout*, the WSC-6 antenna is at left, the WSC-3 antenna is in the center, and a Sea Tel commercial satellite telephone radome is to the right. All three pedestals are adapted to reduce radar reflections, along with the WSC-6 antenna's radome. (*author*)

RQ-8 Fire Scout VTUAV

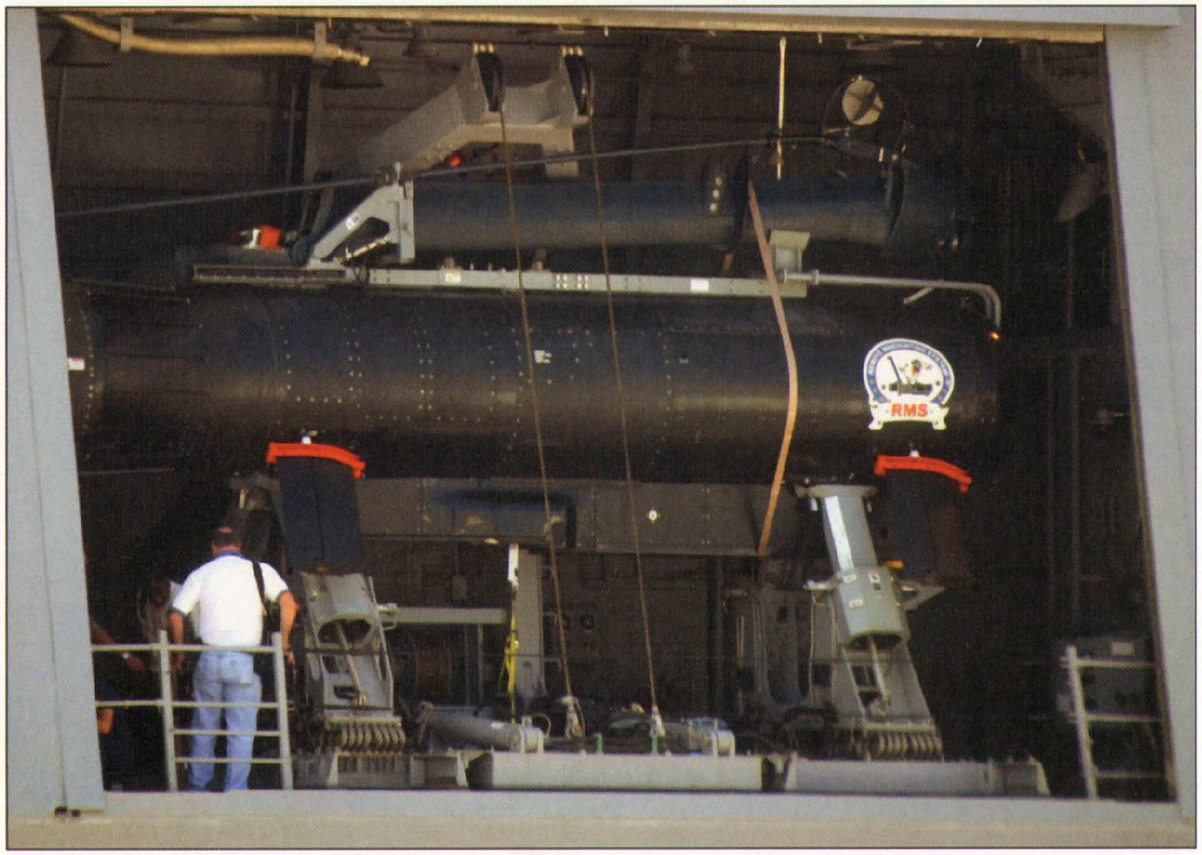
Northrop Grumman's RQ-8A Fire Scout Vertical Takeoff and Landing Tactical Unmanned Aerial Vehicle (VTUAV) test fires a Mk 66 2.75-inch unguided rocket during weapons testing at Arizona's Yuma Proving Ground. The Fire Scout has the ability to autonomously take off from and land on any aviation-capable warship and unprepared landing zones. It has an on-station endurance of more than four hours. (*Northrop Grumman*)

RQ-8 specifications

Height ..... 9 feet, 5 inches
Gross weight ..... 2,550 pounds
Engine ..... Rolls-Royce Allison 250-C20W
Engine shaft horsepower 480
Maximum speed ..... in excess of 125 knots
Ceiling ..... 20,000 feet
Endurance ..... more than six hours
or more than four hours loitering
at a range of 110 nautical miles

The RQ-8 Fire Scout will be deployed on some *Arleigh Burke*-class vessels to conduct surveillance and find, track, and attack targets. It also will provide targeting data to aircraft and surface ships. The Fire Scout can take off and land autonomously from any aviation-capable ship equipped with its specialized data link and control gear. (*U.S. Navy Photographer's Mate 2nd Class Daniel J. McLain*)

WLD-1(V)1 remote minehunting system

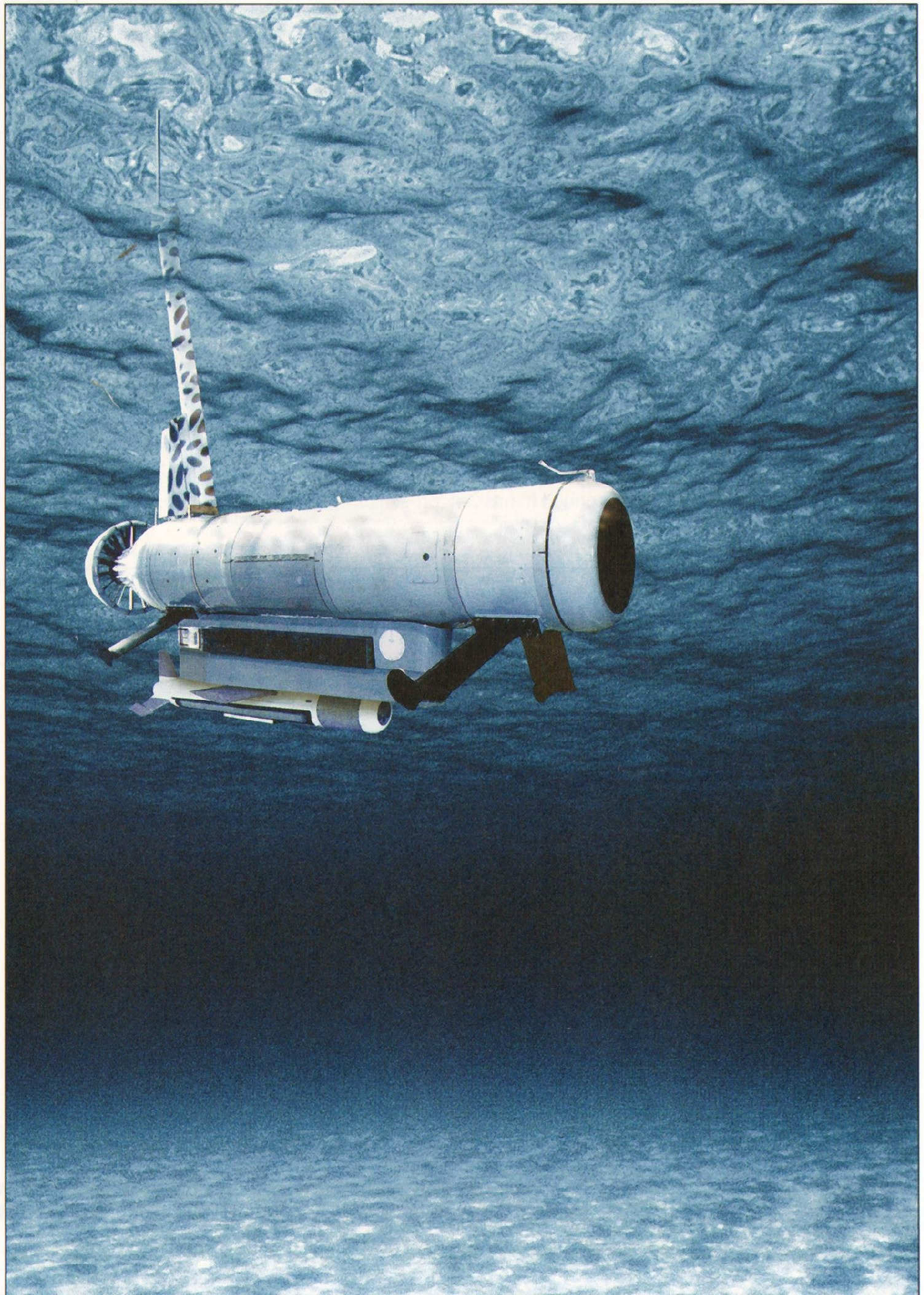


Above: With the WLD-1(V)1 remote minehunting system (RMS), six Flight IIA destroyers will have the capability to deploy a vehicle that can locate, classify, and identify mines while the parent ship stays in safe waters. The RMS can operate autonomously or with manual control. *Momsen* was the only ship outfitted as of 2007. The RMS is stored in a bay along the starboard side. (*U.S. Navy*)

Right: An RMS sails with its mast deployed and the AQS-20 variable depth sonar (VDS) cradled in its belly fairing. The VDS is streamed aft of the remote minehunting vehicle to sweep the bottom with an array of sonar sensors. The mast contains antennas, a video camera, and an air induction system for the craft's diesel engine. (*Lockheed Martin*)

WLD-1(V)1 specifications

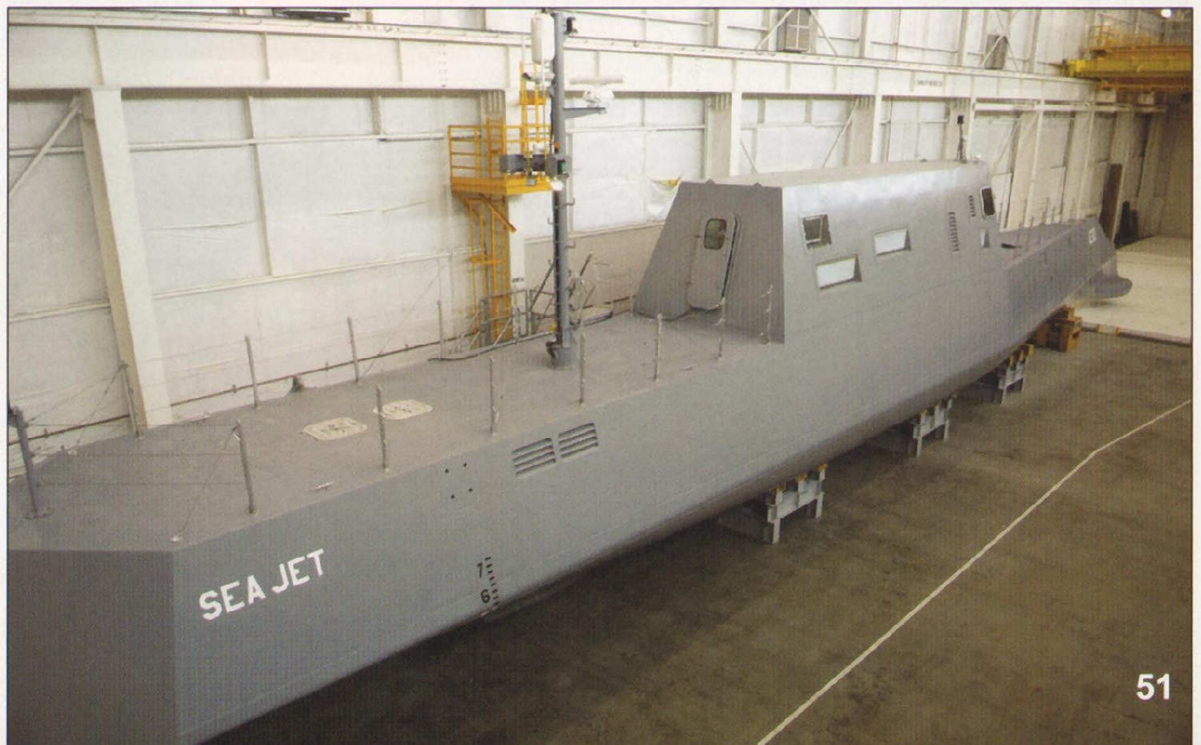
Length overall	23 feet
Weight	12,850 pounds
Speed	approximately 16 knots
Engine	Cummins diesel 370 horsepower
Fuel capacity	289 gallons
VDS tow cable length	2,000 feet



The Advanced Electric Ship Demonstrator (AESD) testbed, named *Sea Jet*, sails on Lake Pend Oreille in Bayview, Idaho. The vessel is testing an underwater discharge water jet built by Rolls-Royce, the AWJ-21, installed to investigate new methods of propulsion for future surface ships. (*Mr. John F. Williams, U.S. Navy*)

Sea Jet is 133 feet long and has a tumblehome bow design with a sonar dome. DDG-1000 will look similar to this trials prototype. (*Mr. John F. Williams, U.S. Navy*)

Sea Jet will serve as a model representing a destroyer-size surface ship to test and demonstrate various technologies. (*Mr. John F. Williams, U.S. Navy*)



Mahan (DDG-72) sits pierside on 20 February 2007 at Port Canaveral, Florida, during a scheduled port visit. (*U.S. Navy Cmdr. R.K. Lovell*)

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